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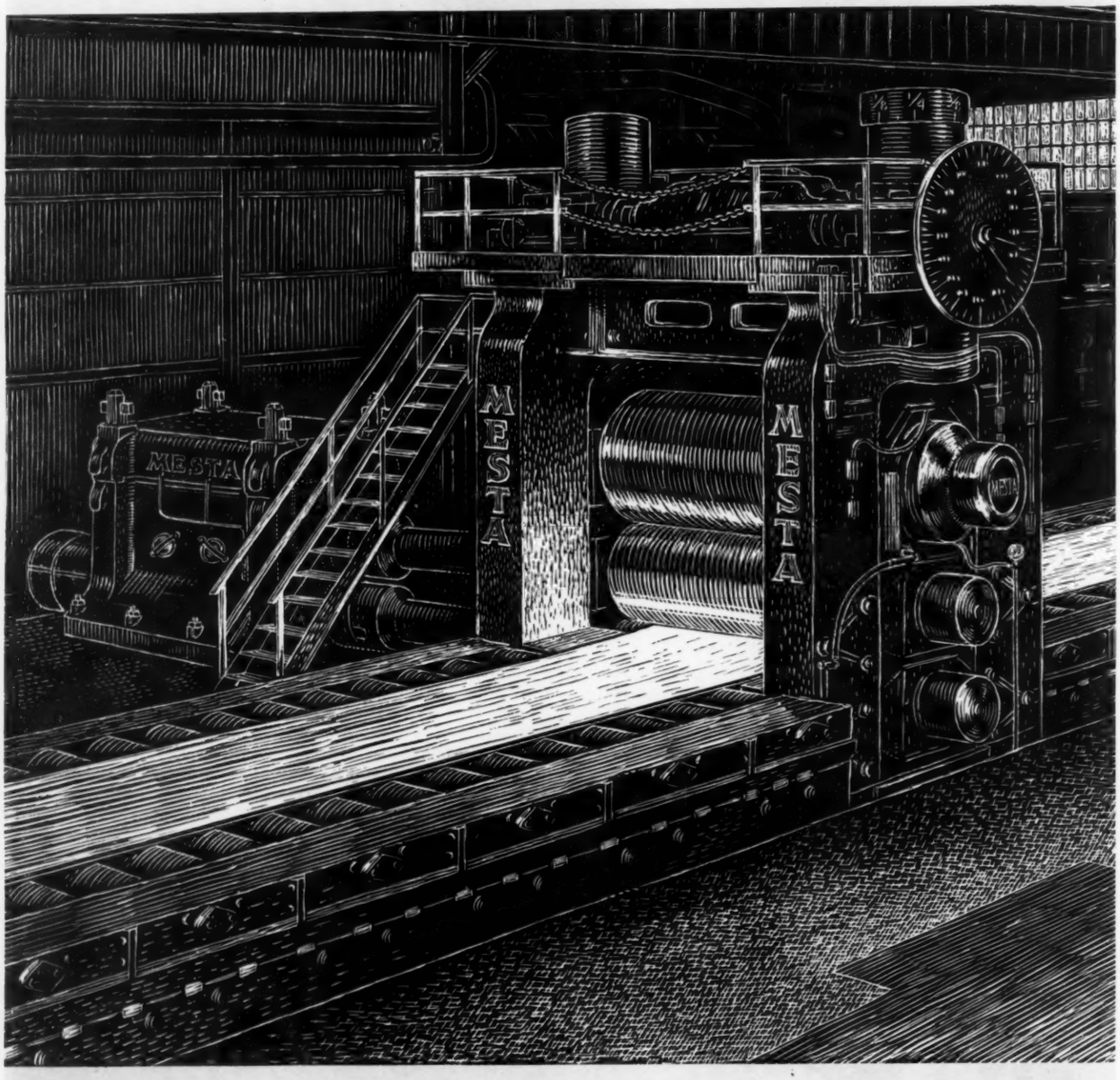


MESTA MACHINE COMPANY • PITTSBURGH, PA.

DEMAGNETIZING and IR DROP COMPENSATION for Cold Mills

By G. E. STOLTZ, Manager, Metal Working Section
Industrial Department, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania.

Presented before A. I. S. E. ANNUAL CONVENTION, CHICAGO, ILLINOIS, SEPTEMBER 24-27, 1940

▲ THERE have been few developments in industry so spectacular and rapid as the continuous cold rolling of sheet and tin plate. Electrical manufacturers supplying equipment for these mills have been pressed to parallel the progress made by the operating steel companies and mill manufacturers. From a maximum delivery speed of 360 ft. per min. in 1928 the speed of rolling tin plate has been stepped up to 2500 ft. per min. this year.

It has become the practice to roll cold strip with tension so that the gauge obtained is the combined result of roll pressure and tension. The roll pressure is fixed by the setting of the screws while tension is determined by the speed adjustment of the individual driving motors.

The ease with which uniform gauge is maintained is very largely a function of the speed characteristics of the driving equipment. Special attention therefore has been given to the design of cold mill motors to obtain flat speed regulation.

Three characteristics are largely responsible for a variation in the speed of a direct current motor with a change in load. They are as follows:

1. *IR* drop of the armature circuit.
2. Armature cross magnetization of the field.
3. Commutated armature coil demagnetization of the field.

ARMATURE IR DROP

At all times there must be a balance of voltage between d-c. machines on the same bus. The sum of the counter electromotive force of the motor armature and the *IR* drop of the motor armature circuit must always be equal to the generator voltage. If the *IR* drop increases due to increased armature current, the counter electromotive force of the motor will decrease to compensate for this change. Neglecting any effects on the field the change in counter electromotive force is accomplished by a proportional change in speed. If a generator is developing 600 volts and a motor, connected to the same circuit, is running idle, it must generate a counter electromotive force of 600 volts. If the motor is required to deliver full load and the total armature circuit resistance is of such a value as to cause a 20 volt drop, the motor will only be required to generate a counter electromotive force of 580 volts. If the no load speed of the motor is 300 rpm., the speed at full load would be 290 rpm., if the *IR* drop were the only factor affecting speed due to changes in load.

ARMATURE CROSS MAGNETIZATION OF THE FIELD

The flux distribution in the simplest form of a direct current motor both at no load and load is shown in Figure 1. With no load on the motor the shunt field flux is symmetrically distributed throughout the cross section of the field poles.

Under loaded conditions the armature coils develop magnetic flux around their conductors. Due to the close spacing of the conductors, those under a pole form a ring of flux in the armature iron and the pole face as shown in the lower sketch of Figure 1. This is armature cross magnetization. This cross armature flux tends to force the field flux to one side of the pole. The crowding of the flux to one side of the pole and the addition of the armature cross flux in the pole face increases the saturation in this portion of the pole. This crowding of the magnetization into a smaller section reduces the amount of flux somewhat in proportion to the load current. In order to maintain its counter electromotive force as the field is thus weakened due to this distortion the speed of rotation of the motor must increase.

Neglecting other effects on a direct current motor, cross magnetization will cause the motor to rise in speed with increase in load and decrease in speed as the load falls off.

The detrimental effects of cross magnetization are overcome by the installation of a compensating winding placed in the face of the main poles. This winding is connected in series with the armature and is provided with the proper number of turns so that its magnetic

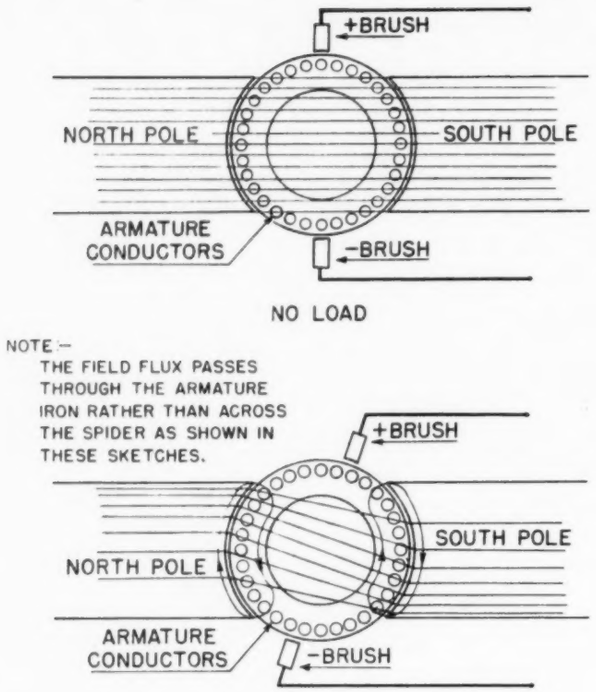


FIGURE 1—Diagrams showing flux distribution in simple d-c. motor at no load (*top*) and under load (*bottom*).

effect is equal and opposite to that of the armature cross magnetization. Figure 2 is a photograph of the stator of a direct current motor designed with pole face windings. In this instance rectangular copper bars are placed in slots in the pole face next to the air gap.

COMMUTATED ARMATURE COIL DEMAGNETIZATION OF THE FIELD

The armature conductors between poles set up magnetization just as those coils under the pole face, but they are too far from the pole to have any material effect on the field of the machine.

Short circuited armature turns immediately under the brushes as shown in Figure 3 can have an effect on the shunt field of the motor. On a machine that does not have interpoles, armature coils short circuited by the brushes will tend to strengthen the main shunt field if the brushes are on neutral. The short circuited armature turns of a machine which has interpoles may either strengthen the field, weaken it or have no effect depending upon the amount of compensation in the interpole winding.

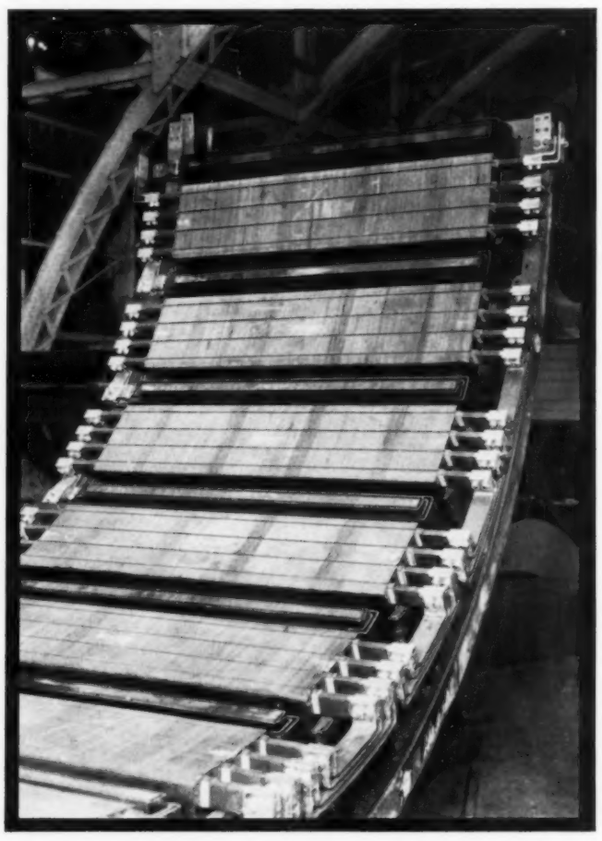
If the interpole or commutating field strength is such that its effect just equals the reactance voltage of the coils being commutated, these short circuited turns will have no effect on the field with change in load. Designers, however, have found it good practice to overcompensate so that the commutating pole winding not only offsets the reactance voltage but reverses the current in the coils that are under the brushes during the early part of the commutating period. This overcompensation sets up a flow of current in the short circuited armature coils in a direction which weakens the main field flux. If the commutating pole winding should be such that the machine is under-compensated, the flow of current in the short circuited turns will be such as to strengthen the field with increase in load.

A normal design utilizes commutating pole windings that are over-compensated so that the short circuited turns under the brushes tend to weaken the main shunt field. Neglecting other influences on the speed of a motor caused by a change in load, commutated armature coil demagnetization will cause the motor speed to rise with increase in load.

This problem is complicated by the fact that the amount of short circuit current flowing in the armature coils under the brushes varies with speed. A greater voltage is generated by the same flux at high speeds than at low speeds. This results in a greater demagnetizing effect at increased speeds, and is rather pronounced on large motors operating at relatively high speeds with a wide speed range of field control.

To offset the demagnetizing effect of such a machine it is necessary to add a series field whose strength is proportional to the load and speed of the motor.

FIGURE 2—This application of pole face windings shows rectangular copper bars in slots in pole faces next to air gap.



A slight modification of this is usually required due to the changing reactance with speed. Compensation for this is obtained by adjusting the voltage of the *IR* drop booster off the voltage drop of the armature circuit.

SINGLE SPEED DIRECT CURRENT MOTOR DESIGNED FOR FULL VOLTAGE OPERATION

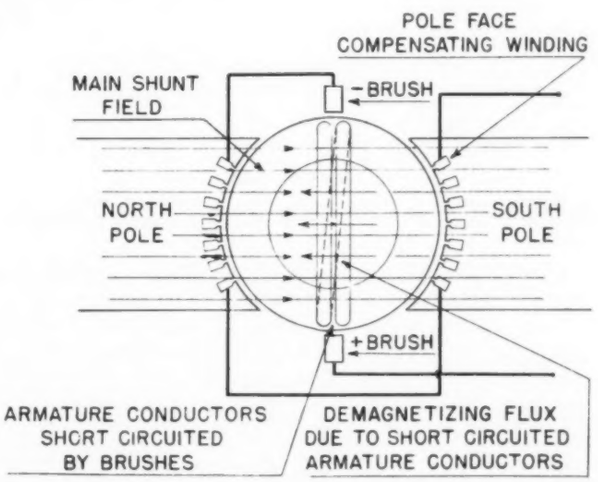
Flat speed regulation on a direct current motor that operates on a constant voltage and at a constant speed is obtained with little difficulty.

The installation of a compensating winding in the face of the poles of the proper value eliminates cross magnetization caused by the armature under any circumstance. This factor can, therefore, be neglected in any further discussion of this subject as it is practice to use motors on cold mills having both a compensating and commutating pole winding.

The armature circuit *IR* drop at a given temperature will be proportional to the load. This tends to make the motor drop in speed as load increases. If this were the only factor to be considered, flat speed regulation could be obtained by placing a series field on the main field poles which would carry the armature load current. With the proper number of turns of series field or with the necessary shunting of this field, a series field can be provided which would be connected differentially to the main shunt field winding, and would have a value to offset the drooping effect of *IR* drop.

The other factor to be considered in obtaining flat speed regulation on such a motor is the commutated armature coil demagnetization. Considering a normal over-conpensated machine operating at constant speed, this demagnetization would tend to cause the motor speed to rise as load increases having just the opposite effect of *IR* drop. To make a correction for this factor alone, it would only be necessary to place a series winding on the main poles that would carry the armature

FIGURE 3—Short circuited armature turns immediately under the brushes may affect the shunt field of the motor.



G. E. STOLTZ

current and would be connected accumulatively with the main shunt field. This winding with the proper number of turns and with correct shunting could be designed to offset the commutated armature coil demagnetization.

Usually this demagnetizing effect on such a machine is greater than the influence of *IR* drop so that the ordinary motor has a winding on its main poles connected in series with the armature circuit, and is accumulatively wound on the poles to compensate for the remainder of the demagnetizing effect not offset by the *IR* drop.

Figure 4 illustrates the relative effects of commutated armature coil demagnetization and *IR* drop of a motor which operates at 600 rpm. The demagnetizing effect alone would cause the motor to rise from 600 rpm. at no load to 648 rpm. at full load. The *IR* drop alone would cause the motor to drop from a speed of 600 rpm. at no load to 582 rpm. at full load. The combined effect of the two would still cause the motor to rise from 600 rpm. at no load to 630 rpm. at full load. To obtain flat speed regulation it is only necessary to add series turns to the field of the correct amount which when connected in series with the armature circuit will have an accumulative effect. If a drooping characteristic is desired, this can be accomplished by further increasing the value of this series field.

Figure 5 is a diagrammatic sketch showing the various field and armature connections to obtain this result.

D-C. ADJUSTABLE SPEED MOTOR OPERATING AT CONSTANT VOLTAGE

An adjustable speed d-c. motor with compensating winding for cross magentization has the same two factors, that is, *IR* drop and commutated armature coil demagnetization, that influence its speed with load. The effect of *IR* drop will not be modified in any way due to the fact the speed of the motor may be adjusted by field control, but the influence of demagnetization

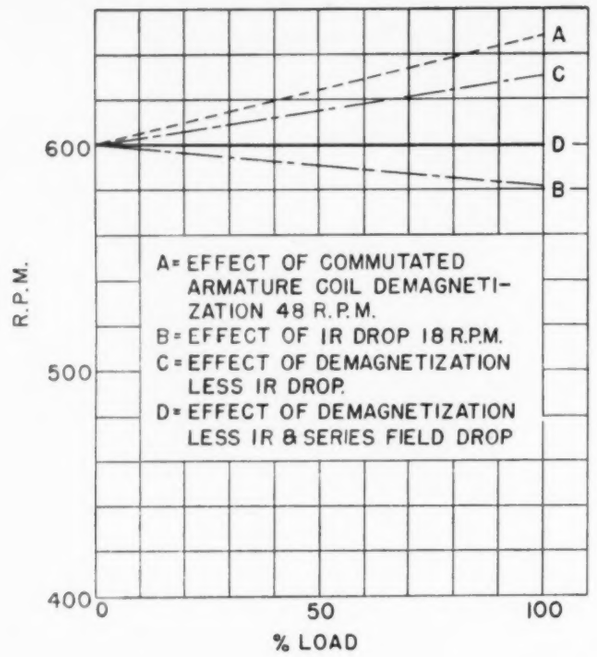


FIGURE 4—Chart showing relative effects of commutated armature coil demagnetization and *IR* drop on 600 rpm. motor.

from the short circuited armature coils will be changed with a change in shunt field strength.

A given amount of interpole flux will generate twice the voltage at 600 rpm. as at 300 rpm. If the overcompensating flux generates 4 volts at 300 rpm., it will generate 8 volts at 600 rpm.

In making this change in speed the reactance voltage is doubled in going from 300 rpm. to 600 rpm. If the reactance voltage is 3.7 volts at 300 rpm., it will be 7.4 volts at 600 rpm.

The excess of .3 volts used to obtain good commutation at 300 rpm. becomes .6 volts at 600 rpm. This means that more current will be flowing in the armature coils being short circuited by the brushes at the high speed than at the low speed so that greater commutated armature coil demagnetizing flux will result at 600 rpm. than at 300 rpm.

In addition to this the main field at 600 rpm. will be one-half the strength of that at 300 rpm. Even though the commutated armature coil demagnetizing effect were the same at both speeds, its effect would be greater on the weakened field than with the strong field.

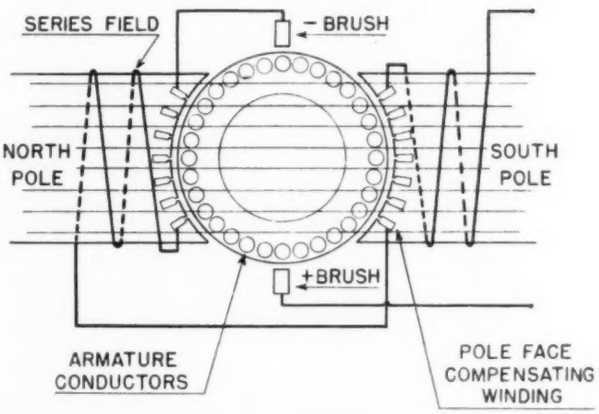
If the speed range of the motor is not too great and the requirements for speed regulation not too exacting, the combined effect of this demagnetization over the speed range and *IR* drop is averaged and corrected by placing a series field on the main shunt field as is shown in Figure 5.

If the application is such that exacting speed regulation is required particularly on a wide speed range motor, a series exciter is used to compensate for the difference between commutated armature coil demagnetization and *IR* drop. The method of using this series exciter is shown in Figure 6. The exciter is operated at constant speed and its field obtains its current by connecting it across the compensating and interpole winding of the main motor. The field current of this exciter is therefore proportional to the load on the motor and with a straight line saturation curve on the series exciter, its voltage will also be proportional to the load. Its effect is, therefore, the same as though the armature current were carried direct in a winding on the main field of the motor except the series exciter provides a convenient means of placing a field rheostat in its armature circuit which is operated from the same shaft as that of the rheostat in a main motor shunt field. The resistance steps of the series exciter rheostat are so proportioned to properly compensate for the difference between commutated armature coil demagnetization and *IR* drop over the entire speed range.

ADJUSTABLE SPEED D-C. MOTOR OPERATING ON VARIABLE VOLTAGE

Cold mills whether they be tandem, or single stand reversing, introduce another variable, and that is, that their speed is varied by changing the impressed voltage on the armature in order to operate the mill at a slow speed when a coil is being threaded through the mill.

FIGURE 5—Diagrammatic sketch showing various field and armature connections to obtain the results shown in Figure 4.



The effect of commutated armature coil demagnetization of a d-c. adjustable speed motor operating over a range of voltage varies with load, strength of the main field, and speed of the armature. Compensation for these three variables can be obtained by the use of a series exciter driven by the motor for which the compensation is being provided. A method of applying such a series exciter is diagrammatically shown by Figure 7. Current from the armature circuit of the main motor is shunted to the field of the series exciter so that

the current flowing in this field is proportional to the load on the motor. To vary this excitation with the strength of the main field a rheostat is placed in series with the exciter armature circuit, its adjustment being mechanically tied to the main motor field rheostat, to compensate for the change in field strength of the main poles. The fact that the series exciter is driven by the main motor means that the voltage obtained from the exciter is proportional to both the load on the motor and its speed, with proper adjustment for the field strength at which the motor happens to be operating. One particular advantage of this series exciter is that its function is to maintain the field strength and not to change it. This method of compensation for commutated armature coil demagnetization effectively eliminates, within design limitations, any influence it has upon the motor speed under all conditions just as the pole face winding removes cross magnetization from consideration.

This simplifies our problem to that of compensating for *IR* drop. If the motor were operated on a constant voltage, this compensation could be obtained by the use of a differential series field but as the voltage is reduced, the strength of this differential field would have to be increased. Further than this, the spread between full speed and threading speed on cold mills as installed at present is so great that it becomes impractical to attempt to weaken the field of the motor enough to maintain flat speed regulation at the reduced voltage. Since the only compensation now required is that of the *IR* drop of the armature circuit, and due to the fact that this is directly proportioned to load only, the logical solution of this problem is to place a separately driven constant speed booster in the armature circuit of the main motor, for which this compensation is being provided. A typical diagram of this is shown in Figure 8 where the field of the booster is excited by shunting current from the motor armature circuit. A rheostat placed in the field of the booster adjusts the voltage of the booster to the value which corresponds to the *IR* drop of the armature circuit. By using a booster with straight line saturation its voltage will be proportional to the load and at the same time always be equal to and opposite that of the *IR* drop of the machine.

This method constitutes a complete and simple method of maintaining predetermined speed relationship under all conditions as required on the present day cold strip mill whether it be of the tandem or single stand with reels. The driving motors operate at all times as though they were under no load, as each disturbing influence is counteracted by a compensating device that directly offsets any tendency to cause the motor to change its speed with load.

FIGURE 6—For exact regulation over a wide speed range, a series exciter may be used to compensate for difference between commutated armature coil demagnetization and *IR* drop.

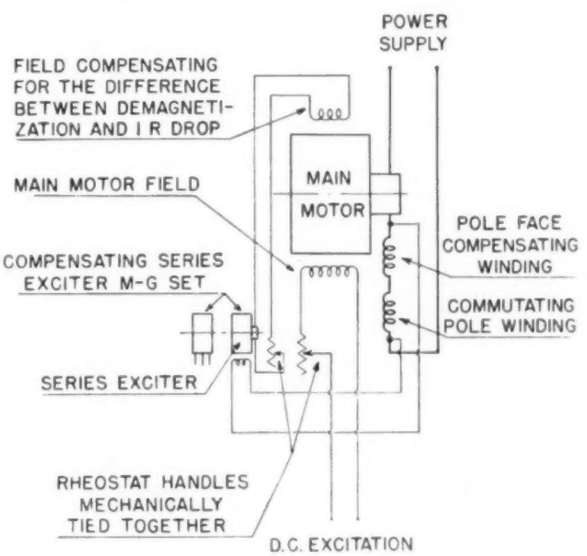
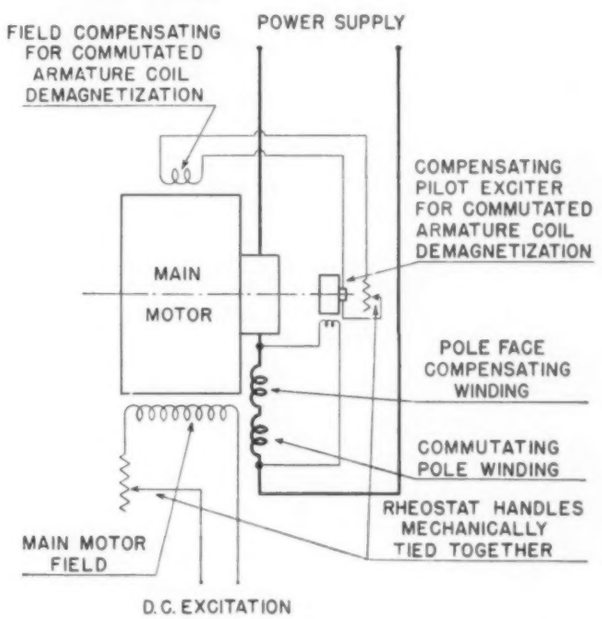


FIGURE 7—Diagram showing method of applying series exciter to d-c. adjustable speed motor operating on variable voltage.


FIELD COMPENSATING FOR COMMUTATED ARMATURE COIL DEMAGNETIZATION
POWER SUPPLY
COMPENSATING PILOT EXCITER FOR COMMUTATED ARMATURE COIL DEMAGNETIZATION
MAIN MOTOR
POLE FACE COMPENSATING WINDING
COMMUTATING POLE WINDING
RHEOSTAT HANDLES MECHANICALLY TIED TOGETHER
MAIN MOTOR FIELD
D.C. EXCITATION

TYPICAL 4-STAND TANDEM COLD TIN MILL

The problem of providing electrical equipment for the present day tandem or single stand reversing cold mill is far more difficult than it was a few years ago. Accelerating and decelerating between a threading

speed of 200 ft. per min. and a rolling speed of 2500 ft. per min. imposes entirely different conditions on motor equipment than that with a rolling speed of less than 400 ft. per min. Further than this rapid acceleration becomes of more value as the difference between threading speed and running speed increases.

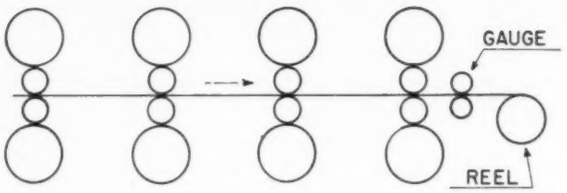
It is more important to carefully design electrical equipment for a mill running at 2500 ft. per min. than one operating at 400 ft. per min. If it is necessary to make some adjustment in tension or motor speed of a mill delivering metal at 40 ft. per sec., a larger amount of off-gauge material will be produced than on one that is operating at 7 ft. per sec.

Figure 9 is a statement of conditions prevailing on typical 4-stand tandem tinplate mill which illustrates some of the problems involved.

If a second is required to accomplish a change in speed of some motor to correct gauge, 40 ft. of off-gauge metal will be rolled while this change is being made.

The thickness of the average product rolled on such a mill is only three times that of a human hair. While the thickness is allowed to vary plus or minus .0005 in., it is usual to keep it within plus or minus .0003 in. In spite of the fact the strip finished is only .01 in. or less in thickness, and is traveling at the rate of 40 ft. per sec., the tolerance in thickness to which this material is finished is less than that usually obtained in machine tool practice.

In addition to having roll pressure in the neighborhood of 1,000,000 lb. per stand applied to the metal, the tension on the metal between stands will be in the order of 30,000 lb. per sq. in. cross section. The speed regulation of the motor equipment must be such that rolling this very thin product at such a high speed and under heavy tension there must be no tendency to break the metal in two or vary its gauge.

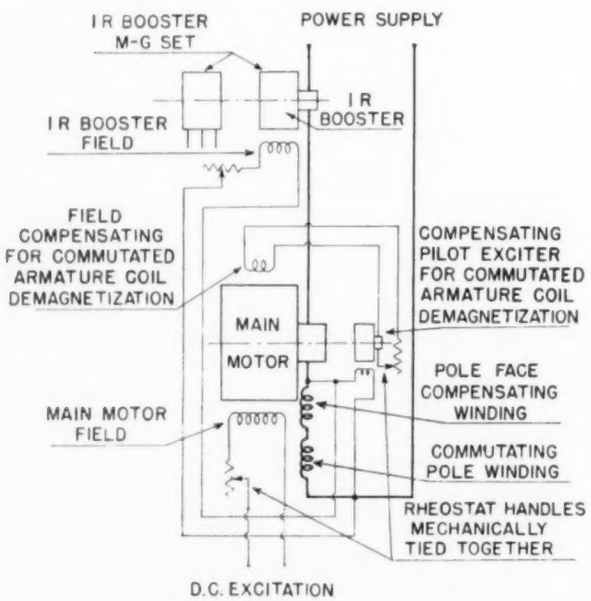


(ROLLING .076"X 28" TO .01"X 28"X 10,000')

1 - DELIVERY SPEED FEET PER SECOND	40'
2 - THICKNESS OF FINISHED PRODUCT.	.01"
3 - TOLERANCE OF FINISHED THICKNESS.	.0005"
4 - CROSS SECTION METAL BETWEEN LAST TWO STANDS.	.335□"
5 - TENSION BETWEEN NOS. 3 AND 4.	10,000#
6 - TENSION PER SQ. IN. METAL BETWEEN LAST TWO STANDS.	30,000#
7 - TOTAL H.P. USED TO DRIVE MILL.	7,000
8 - TIME TO ACCELERATE.	8 SEC.
9 - EQUIVALENT H.P. REQUIRED TO ACCELERATE.	2,000
10 - TOTAL H. P. DURING ACCELERATION.	9,000

FIGURE 9—Conditions prevailing on typical 4-stand tandem tin plate mill, illustrating some of the problems involved.

FIGURE 8—Diagram showing use of booster generator with booster field excited by shunting current from motor armature circuit.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COMMUTATING POLE WINDING
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D.C. EXCITATION

Considering the possibility that these motors may be overloaded at times, there must be available the equivalent in capacity of a 10,000 kw. turbine to handle this mill. One can readily appreciate what it means to the mill operators to have a well balanced design of electrical equipment when it is realized they are rolling such thin product at high speeds, under enormous roll pressures, and high tensions, one instant delivering the metal at 200 ft. per min. and 8 seconds later at 2400 ft. per min. with 10,000 kw. capacity from which the driving power is drawn.

It has been generally recognized that fewer breaks occur at full speed and more uniform gauge is obtained on a cold mill of this type with motors of substantially flat speed regulation.

Motors designed without *IR* drop compensation may have very good speed regulation at full voltage, but this is not the case when they are reduced to threading speed. A mill operating at 2400 ft. per min. which is reduced to a threading speed of 200 ft. per min. means

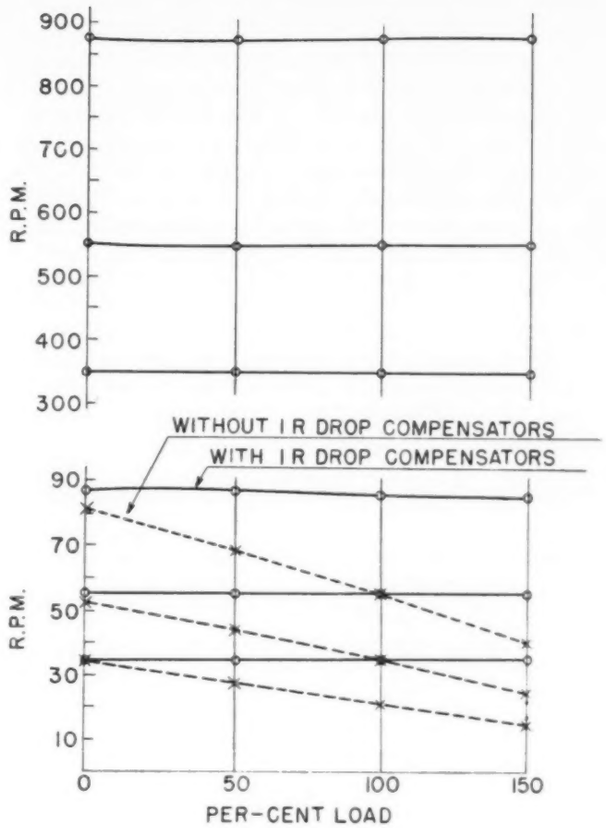


FIGURE 10—Curves showing test value relationships between speed and load with and without *IR* drop compensation.

that the threading speed is one-twelfth of the full load speed or 8⅓ per cent. At such a low threading speed the commutated armature coil demagnetization becomes almost zero while the *IR* drop in the armature circuit of the motor may become one-third of the counter electromotive force required at this time. Particularly if the motor is operating at a weakened field position, it will be impossible to weaken the field sufficiently to compensate for the *IR* drop under this condition.

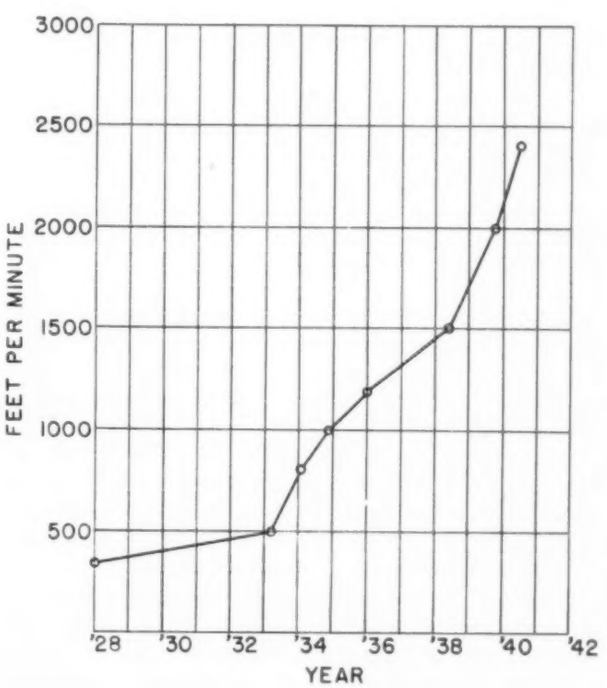
Figure 10 is a curve sheet on a 700 hp. d-c. motor operating from 350 to 875 rpm. The three curves at the top of the sheet represent the test values obtained on this motor with *IR* drop compensation first at fully weakened field, second at an intermediate field and third at full field of the motor, all taken at full voltage. Flat speed curves were obtained under the three conditions of the field.

The three full line curves at the bottom of the sheet are test values obtained using *IR* drop compensation at speeds which correspond to the threading speeds on the mill. It will be noted there is a one rpm. drop at full load from no load with the motor at weakened field, at one-tenth voltage. At the intermediate speed position and the full field speed the curves are flat from no load to full load.

After the test on this motor was completed using *IR* drop compensation a series field was provided to give substantially the same curves at full voltage as are shown at the top of Figure 10. The voltage was then reduced to one-tenth value and speed values taken at weakened field, intermediate field and full field without the *IR* drop compensation. On each of these three curves shown by dashed lines the speed drop from no load to full load is substantially 30 per cent.

If we assume a mill such as is shown in Figure 9 set up with each set of rolls operating at the correct speed to draft the steel as is required, at 2400 ft. per min., this same speed relationship should prevail in order to avoid breakage of strip or unnecessary change in gauge as the mill is retarded to threading speed. If the motors are not provided with commutated armature coil demagnetization and *IR* drop compensation, the speed assumed by each individual motor will depend upon the speed regulation and the load which the motor happens to be carrying. An illustration of this would be to assume that the 700 hp. motor, the speed curves of which are shown in Figure 10, would be operating on its weakened field at full voltage at a speed of 875 rpm. This speed would be sustained regardless of the load as long as the voltage remains at its full value. When the mill is brought to its threading speed the motor would be operating on the upper dashed line curve shown in the lower half of this figure. Certainly the synchronization of the mill as established at full speed would not be maintained and it would only be natural

FIGURE 11—From a maximum delivery speed of 360 ft. per min. in 1928, tin plate cold reduction has increased to 2500 ft. per min. in 1940.



to expect off-gauge metal and a possibility of breaking the metal between stands. If the motor equipment is designed so that under varying voltage conditions its speed is not changed by load, the mill will maintain the same synchronization as it swings from full running speed to threading speed and back again.

The first mill equipped with this type of demagnetization and *IR* drop compensation is the No. 4 four-stand tandem tin plate cold reduction mill at the Weirton plant of the Weirton Steel Company. This mill was started the first week in April, 1940, and has shown distinctively improved operating characteristics from its start.

If the front end of the coil happens to be off-gauge, the strip can be brought on gauge within 4 to 6 wraps of the reel. While the mill may be slowed down to threading speed the gauge is not off allowable tolerance until the tail end of the coil is part way through the mill. On occasions we have seen the mill slowed down to threading speed and returned to full speed in the middle of the coil without any appreciable variation in the meter which indicates gauge of the strip.

There is no necessity of balancing loads in order to obtain good operation. The first coils put through the mill, before the operators had an opportunity to adjust the drafts, imposed a wide variation of load on the driving motors. The motor on stand number one had approximately no load, number two, 90 per cent, number three, 150 per cent and number four, 240 per cent. This is not a normal rolling condition but, in spite of the wide discrepancy in loaded conditions of the four motors the mill accelerated and retarded in synchronization, at rapid rates as though the motors were all operating with no load. This is just what commutated armature coil demagnetization and *IR* drop compensation does for an adjustable speed compensated d-c. motor. This compensation is such that regardless of load, voltage, or speed, the response is as we would expect from a motor at no load, reacting at all times in proportion to the voltage imposed upon it.

The comment of the mill operators is that this mill can be accelerated or retarded as rapidly as possible even under emergency conditions with no apparent tendency to place the strip under any other tension than that obtained at full speed, which means the tendency to tear the steel in two at reduced speeds has been removed as far as the motor equipment is concerned.

More uniform gauge is obtained at full running speed on this mill than has been obtained from similar mills in this same plant. This means that the speed regulation of the motors is held more closely at full voltage than without the *IR* drop compensation.

We have recognized for some time the performance of our previous electrical equipment would not be as good on later higher speed mills, but this limitation has been removed by the introduction of commutated armature coil demagnetization and *IR* drop compensation.

In addition to obtaining better gauge both at running speed and at lower speeds, there is less tendency to tear the steel in two, the mill responds better and more accurately to changes made by the operator, and as a whole it is easier to handle. This results in less delay and an increase in tonnage output not only due to increased delivery speeds but also continuity of operation.

The speed of rolling tin plate on tandem mills has been increasing steadily for several years. It seemed for a while that a limit had been reached, but the Weirton mill started off above 2000 ft. from the beginning and has operated as high as 2700 ft. The introduction of commutated armature coil demagnetization and *IR* drop compensation has removed the speed limit of rolling tin plate as far as electrical equipment is concerned. Figure 11 is a curve showing typical delivery speeds of tin plate mills over a period of time from 1928 to 1940. Today the limitation in speed is in the hands of the mill operator as the electrical equipment as now installed on the Weirton mill opens this situation up again and as far as we are concerned, this curve can be continued on up at the same rate it has been increasing in the last few years.

DISCUSSION

PRESENTED BY

I. N. TULL, *Electrical Superintendent*, Republic Steel Corporation, Cleveland, Ohio.

A. W. DUNCAN, *Electrical Superintendent*, Weirton Steel Company, Weirton, West Virginia.

L. A. UMANSKY, *Assistant Manager*, Industrial Engineering Department, General Electric Company, Schenectady, New York.

H. H. ANGEL, *Control Engineer*, Bethlehem Steel Company, Sparrows Point, Maryland.

JAMES FARRINGTON, *Electrical Superintendent*, Wheeling Steel Corporation, Steubenville, Ohio.

G. E. STOLTZ, *Manager*, Metal Working Section, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania.

I. N. TULL: This is an exceptionally interesting paper. The subject is live, in that there are a number of mills that have had difficulties in tearing steel in two, and that sort of thing. Apparently this is one way of solving the problem.

It is not disclosed in the illustrations just what these compensators look like physically. Those of you who have not seen them should visualize an armature of the same current capacity as the main motor armature with which it is associated, although its voltage is of the order of 40 at normal load. Naturally this is rather an expensive piece of equipment and its justification has to be proven. As with other innovations, the first installation is sometimes difficult to sell management, but after someone has proven the case, others don't have the selling problem to such a degree. At least, this has been the history of other similar problems.

In this case, Mr. Duncan, electrical superintendent at Weirton Steel Company, pioneered the application in his plant, and is getting his mill up to the speed they expected to, and, I understand, with gratifying results. I would like to hear Mr. Duncan tell about his experi-

ences with this first installation of *IR* drop compensation as applied to tandem cold mills.

A. W. DUNCAN: This matter of rolling light gauge steel, particularly tin plate, has been more or less of a nightmare to us who have had to contend with it over a number of years. We started out with our tin plate tandem mill operation some few years ago with a little mill operating at 280 ft. per min., and a short time later a mill was designed to operate at 600 ft. per min. That was tops—the last word from the standpoint of speed. A couple of years later this 600 ft. mill was redesigned and made to operate at 1100 ft. per min. An additional mill was designed and built to operate at 1350 ft. per min. which again was the absolute top speed. This 1350 ft. mill is operated today at 1500 ft. per min. The 1100 ft. mill previously referred to was again redesigned on the basis of 2000 ft. per min.

With your permission, I will digress a little from the method of control as covered by Mr. Stoltz's splendid paper and attempt to give you an idea of some of the problems that have to be met in the application of electric equipment to tandem rolling mills which explanation I hope will justify in your minds the necessity for the most sensitive and positive control obtainable. This is particularly true of mills rolling the lighter gauges, such as tin plates and galvanized stock.

In the mill Mr. Stoltz referred to in his paper, the horsepower ratings as he covered them were for:

No. 1 pass— 700 hp.—350/875 rpm.
No. 2 pass—1750 hp.—300/600 rpm.
No. 3 pass—1750 hp.—175/350 rpm.
No. 4 pass—2500 hp.—250/500 rpm.
Reel— 300 hp.—175/600 rpm.

This reel motor, by the way, is a 60-degree motor, while the others are 40 degree motors.

The theoretical speed ranges required for the proposed schedules were as follows:

2 to 1 for No. 1 pass
1.75 to 1 for No. 2 pass
1.75 to 1 for No. 3 pass
2.06 to 1 for No. 4 pass
5.65 to 1 for reel

The speeds finally decided on are as follows:

2.5 to 1 for No. 1 pass
2 to 1 for No. 2 pass
2 to 1 for No. 3 pass
2 to 1 for No. 4 pass
3.4 to 1 for reel

The No. 4 pass motor is the largest both from a horsepower and physical standpoint, the most expensive, and the most difficult to control, besides driving a stand at which the steel is the most sensitive to speeds and tension changes. Inherently, the smaller the speed range of a direct current motor, the more stable is its operation, and the cheaper its cost. Therefore, 2 to 1 was selected for this stand, instead of 2.06 to 1, requiring certain schedules to be rolled at a speed 3 per cent different than those proposed, and usually on the faster side. The speeds for No. 2 and No. 3 passes were made 2 to 1 so that the operators would have some latitude in the drafts taken on these mills, without certain schedules coming outside the speed funnel on the worst condition of roll sizes.

No. 1 stand motor is the smallest and cheapest motor on the mill. Also, due to the small size of this motor and to the relatively slow speed at which this stand runs, the stored energy in the rolls, wobblers, pinions, gears and motor, all referred back to the motor shaft, is very small, being one-fourth as much as stand No. 2 and one-tenth as much as stand No. 3. Therefore, an increase of its speed range from 2:1 up to 2½:1 is negligible in cost, and its effect on mill stability. Incidentally, the steel strip at this pass is at its heaviest gauge and least sensitive to any speed variations that might occur.

This extra range compensates for the 0.06 dropped from No. 4 pass, besides permitting sheet schedules from 0.0152 in. in gauge on up to the heaviest gauge being rolled at higher speeds than requested if it is so desired and the horsepower of the drives is not exceeded, which should not occur due to the smaller reductions taken on these heavy gauges.

It is a well known fact that in cold rolling of thin gauge strip, the gauge is heavy until rolling speed is reached or nearly reached. This causes so-called off-gauge heavy ends, and undesirable scrap loss. The longer the time needed to accelerate and decelerate, the greater is this scrap loss, everything else being equal. On a mill with sufficient power this loss is decreased by putting greater than normal tension on the strip during acceleration, and gradually decreasing this value manually as the speed approaches rolling speed. Of course, during deceleration the procedure is reversed. By this means it is possible to obtain gauge at from 40 per cent to 50 per cent of rolling speed.

The per cent of full load torque to accelerate a standard 2 to 1 speed range direct-current mill motor from base speed to maximum speed in one second, is the full rating of the motor. Therefore, when rolling load must be carried at the same time that the motor, gear reducers, and mill are accelerated, it is obvious that the greater the stored energy is in these parts, the longer the accelerating time must necessarily be, in order to keep the overload on the motor to a value that it can pull.

From this it follows that the lower the WR^2 of mill and motor, the shorter the accelerating time possible; and the shorter the accelerating time, the less heavy gauge produced. During deceleration this condition is improved, because the stored energy of the rotating parts need not all pass through the motor, because some is consumed as rolling load.

It is also a known fact that if the internal resistance of all the motors and the stored energy of each stand of a tandem mill, including rolls, pinions, gears and motors, are all equal, the mill stands will all accelerate or decelerate uniformly, and the speeds and tensions set between stands will be maintained. However, practically, this condition is impossible of attainment for two reasons. First, consider the stored energy of the individual stands, which is different for each one because of the different speeds at which the rolls run and different gear ratios, even if all the motors were identical. Since they are not, this introduces another unbalance.

The first stand with the slowest speed has the minimum WR^2, No. 2 stand the next highest, etc., with No. 4 stand the maximum. If the stored energy of the stands was zero, they would be balanced; therefore, this is

another reason it is imperative to approach this minimum as close as it is economically and mechanically possible. Since the diameter, length and neck size of the rolls, size of the wobblers, and of the pinions, is determined by mechanical reasons, the only thing left that can be changed is the gears and motor armatures. On slow speed stands the motor armature is the major part of the WR^2, but on high speeds the mill has the most.

For this reason, No. 4 stand has a certain WR^2 below which it is impossible to go. To obtain the minimum this stand is direct driven, eliminating the gear drives. The motor is also specially designed with twin armatures, causing a long, small-diameter motor, each armature of smaller diameter and longer than standard, and has forced ventilation for cooling.

No. 3 stand would have a total stored energy with respect to its horsepower rating greater than No. 4 stand if a standard motor and geared speed reducer were used. To lower this value the gear reducer was eliminated and a standard motor of correct slow speed used; that is, 175/350 rpm. This gave a value slightly lower than No. 4 for all tin plate schedules. Incidentally, the increased cost of a direct drive motor was considerably less than the bare cost of reduction gearing. The maintenance and wear on large, high-speed gears was eliminated for all time. A satisfactory value of stored energy was secured for No. 2 stand, with standard motor of comparatively low speed for gear reducer of 3 to 1 ratio. No. 1 stand has a gear ratio of approximately 7.03 to 1, and due to slow speed this has lower value of stored energy than any other pass.

On any mill, rolling a variety of gauges the relative speeds of each stand is different for each schedule rolled. For instance, in rolling the lightest gauge, No. 1 pass would run near its minimum speed, where No. 4 pass would run at its maximum speed. No. 2 and No. 3 passes would run at speeds of intermediate values. This means that No. 1 motor would have full field strength, while No. 4 motor would have minimum field strength. At constant armature voltage, the torque of a direct-current motor is proportional to its field strength.

The stored energy of mill and motors can be so proportioned as to be approximately balanced for any given rolling schedule at some definite speed, but for any other schedule or speed they would be unbalanced. This fact shows another reason for low value of total WR^2 on mill.

The success with which the desirable low and balanced stored energy was approached for this mill is shown by the following figures of per cent full load motor torque required to accelerate the four mill stands in eight seconds' time, for characteristic tin plate schedules, using one manufacturer's values of motor WR^2, and finishing at 2000 ft. per min.:

For finishing 0.0086 in. strip:

No. 1 stand	13.1 per cent
No. 2 stand	12.75 per cent
No. 3 stand	18.0 per cent
No. 4 stand	22.9 per cent
Reel	19.7 per cent

Other schedules will vary somewhat but follow a similar vein:

For finishing 0.0115 in. strip:

No. 1 stand	23.5 per cent
No. 2 stand	21.3 per cent
No. 3 stand	22.5 per cent
No. 4 stand	22.9 per cent
Reel	19.7 per cent

The desirableness of these figures is further appreciated when it is recalled that one of our tin plate tandem mills requires 35 to 40 per cent full load torque to accelerate in 15 sec., and one of the newer mills of the industry requires 60 to 80 per cent full load torque to accelerate in 8 sec. Incidentally, the latter values are so high that very little excess tension can be put on the strip during acceleration, with the result that that mill must be nearly to speed before gauge is reached.

Previously, the internal resistance of the mill motors was mentioned as affecting the speeds of various motors and the relative tension between stands during acceleration and deceleration. It is possible that these resistances could be made the same, but due to the inherent design of machines for a tandem mill with tapered horsepower the largest horsepower, such as on No. 4 stand, is low, whereas the reel, with smallest horsepower and greatest speed range by field control (required for coil build-up), has the highest resistance. Although it is possible to make the resistances the same, it would result in a very expensive set of motors. If they were the same, the internal voltage drop would be the same as long as the loads were the same as that for which the resistances were designed. As soon as the load of any one motor changes, there would be an unbalance. The load balance changes for each different schedule rolled, and for every different speed at which it might be rolled. Consequently, making internal resistance of all motors the same is not a solution for securing balanced armature drop.

It was decided to attempt to solve this difficulty by the use of auxiliary generators in series with the armature of each individual motor. This generator produces a voltage in addition to that supplied by the main motor generator set that is directly proportional to the load, and so completely neutralizes the armature drop of the mill motors, no matter whether they are running at thread voltage, full voltage, weak field or full field.

Besides uniform gauge and minimum scrap loss, the stability of a mill and maintenance of uniform tension avoids slack between stands, or excess tension during acceleration or deceleration, either of which usually tends to cause wrecks, such as broken strips caused by running into guides or loss of tension, and tearing in two or pulling apart by excessive tension. Quite frequently these wrecks ruin a set of work rolls, requiring a delay while they are changed. Even small delays mean a great deal more lost production on a high-speed mill than on a slower-speed mill.

The speed of tandem tin plate mills has skyrocketed in the past few years, and each time a new speed was used there was a question about the maximum economical speed possible. One time, cooling of mill and strip was thought to be a limiting factor. This seems to have been solved satisfactorily.

Another thing was ratio of rolling time to threading, accelerating and decelerating time. The faster the rolling speed, the smaller this ratio. This has been increased by longer coils, and may possibly be further extended by welder developments permitting rolling of double length coils. The greater the rolling speed, the longer time for acceleration and deceleration, using the

same speed of acceleration; the longer time for acceleration the longer are heavy ends, both front and rear ends of coil. This has been improved by decreasing accelerating time by using minimum inertia motors and drives.

Mr. Stoltz, in his paper, mentioned this mill was being accelerated in a period of eight seconds. I am going to have to correct him on that, as it is being continuously accelerated in 7.6 sec. The common run of tin plate in all sizes is being continually rolled at from 2200 to 2400 ft. per min. The speed at which it is rolled may depend on the condition of the steel coming from the hot mills, or it may depend on the attitude of the operator. There is no reason electrically why he could not roll 2400 ft. per min. at all times.

The threading speed on this mill is 475 ft. and when we get down to gauge at about 1000 ft. per min., the gauge is maintained throughout the entire rolling process of that particular coil, until the piece drops out of the No. 2 stand, at which point gauge is lost and there are no electrical adjustments necessary in the rolling of any schedule to maintain stable operating characteristics.

I might add that with the method of control used on this mill it is possible to stop the mill by the use of the emergency stop button, thereby decelerating from 2200 ft. to a standstill in 3.8 sec. without causing a break in the strip and to my knowledge there has been no strip broken on this mill, which can be attributed to off-tension either during accelerating or decelerating periods.

Our experience in the operation of this mill proves to our satisfaction that the *IR* drop compensation control method, as so well covered by Mr. Stoltz, will do the job exactly as it should be done.

L. A. UMANSKY: It is, indeed, gratifying to me, as an electrical man, that—for the third consecutive annual convention—papers dealing with the improvement of cold mill rolling practices were presented by men of my profession. This fact illustrates better than any words could to what extent the art of rolling cold strip depends on the electrical equipment, and to what extent the latter has become an integral part—maybe the most important part—of the mill itself.

The importance of *IR* drop in motor armatures for cold mill drives, and the possibility of using the line boosters was clearly stated two years ago at Cleveland by Messrs. Rhea and Leding (IRON AND STEEL ENGINEER, May 1939, page 30). Thus, I have no exception to take to Mr. Stoltz's thesis that the compensation of this *IR* drop will make the problem of mill acceleration easier of solution. Undoubtedly the per cent scrap due to off-gauge material during acceleration and retardation can be reduced. The real problem is, however, this: How much will it be reduced, and will this saving be worth the extra investment?

Let me cite to you the example given in this connection by F. Mohler which appeared in the IRON AND STEEL ENGINEER, December, 1939, page 44. A coil with finished length of 6000 ft. is rolled at a speed of 2400 ft. per min. and threading is done at 400 ft. per min. The mill is brought to full speed in, say, 8 sec., and is retarded in 5 sec. Thus, the length of strip delivered during the acceleration from 400 to 2400 ft. per min. is only 133 ft., and during decelerating period, only 83 ft., or a total of 216 ft. or 3.6 per cent of total length.

Now a good cold mill control should—and does—provide the so-called tapered tension during acceleration and retardation periods. This means that the tension between the stands is increased while the strip speed is low, and is gradually returned to normal as full speed is reached. In this manner the strip is brought "on gauge" at less than 50 per cent speed. This reduces the amount of the off gauge material, in the above example, to only 70 ft.

Now, according to Mr. Stoltz, the use of line boosters brings the strip "on gauge," after 4–5 wraps on the reel; *i.e.*, after about 25 ft. of material has been rolled. Allowing an equal amount for the deceleration period, we should get, say, 45–50 ft. of off gauge strip for a mill discussed by Mr. Stoltz.

It would be interesting to take a mill equipped with line boosters, to operate it for a certain length of time with and without them, trying in either case to get the best possible results, and then to compare these results.

It may not be amiss to state that a new cold strip mill for tin plate production is being built now. It will have a record breaking maximum speed of over 3500 ft. per min., with a total of about 11,000 hp. in driving motors. In building the electrical equipment for this mill we were given the task of providing the line boosters, but to have the control arranged in such a manner as to operate the mill with or without them. This installation should be able to furnish interesting figures on the comparative performance.

H. H. ANGEL: I remember very distinctly two years ago, at a similar meeting, somebody asking the speaker, or anybody caring to answer, what would be the speed limitation of the near future. At that time there wasn't any answer forthcoming. I think Mr. Stoltz's paper and the comments of the other men, have given us some of the practical results they have obtained in the last few years.

We have a couple of cold tandem mills in our plant at Sparrows Point. They, of course, are running at a much slower speed than 2400 or 3000 ft. per min. On our No. 1 mill, which was speeded up around the first of this year, we have arrangements made to vary the series field strength of the motors on the five stands. We also have means of obtaining tapered tension. The operating department claims the results have been very gratifying. One of the big factors in obtaining better gauge has been the decrease in time to accelerate and decelerate. However, it is a problem which varies with the skill of the various operators. Some can roll much better than others and the number of breaks can be reduced. It may be, as Mr. Stoltz has pointed out, that when you obtain constant speed over the various ranges of voltage and load, you may automatically compensate for the inability of some operators to handle the mill as well as others.

JAMES FARRINGTON: I just want to say that what Mr. Stoltz told you is the truth. Sometimes these salesmen tell us things about the machines we purchase and then we have a very hard time to make the machinery come up to their recommendations.

Some time ago we put into operation a four-stand cold mill. Our old mill had a maximum rolling speed of 360 ft.

per min. and was put in in 1931, and we continued to roll at 360 ft. per min. The new mill has a top speed of 1600 ft. per min., rolling from .093 in. down to .014 in. In that time, we not only had to educate the mill men, but break in the mill. The men have operated the mill up to 1500 ft. per min. in the two weeks with very gratifying results. One of the things we are all interested in is preventing the steel from breaking in case of an emergency stop. We were rolling 0.015 in. strip at 1250 ft. per min., had an accident and stopped the strip in 3 sec., the strip remained taut without breaking. So we feel that we have been given a wonderful piece of equipment, and we expect, probably, to have the mill up to 2000 ft. per min. to keep in line with the rest of our competitors.

G. E. Stoltz: Mr. Duncan has presented a very fine discussion of the paper. It is obvious that he has given the selection of the drive for his mill very careful study, which is largely responsible for its good performance.

He has stated that the time of acceleration on this mill is 7.6 sec., while I used a value of 8 sec. The time of acceleration and retardation is adjustable by changing the speed of the motor operating the field rheostat of the generators. The selection of the rate of acceleration and retardation is therefore left to the operators and it may be adjusted from time to time to suit their convenience.

Mr. Duncan has also reported that they have worked up to a threading speed of 475 ft. per min. out of No. 4 stand. In my paper I had used the value of 200 ft. per min., which until recently has been the general practice of most mills. While we were familiar with the fact that higher threading speeds were being used on this mill, there are times and conditions which do not permit this. Higher threading speeds should be obtained on mills equipped with motors with *IR* drop compensation than without it, but the threading speed also depends upon the operating crew and mill conditions. For this reason a report on the accomplishments of this mill in regard to threading is of more value coming from an operator than the motor manufacturer.

Mr. Umansky refers to a paper by Messrs. Rhea and Leding presented before the Cleveland Convention two years ago, which he says clearly states the possibility of using line boosters.

This paper attempted to meet this problem by considering *IR* drop of the armature circuit alone, neglecting the effect of short circuited armature coil demagnetization. They then developed a theory of compensating for difference in inertia due to the fact that a motor having large inertia draws heavier current, and due to the increased *IR* drop operates at a slower speed. This is satisfactory as far as it goes, but it should also be recognized that one motor may have a heavier mill load than another. They finally conclude that their theory does not check quantitatively. This is the only natural thing to expect as the effect of armature demagnetization is too large a factor to be ignored.

I hope that neither my paper nor Mr. Duncan's discussion has misled anyone to believe that the only purpose of *IR* drop compensation is to roll more sheet on gauge. While this is one of the results, *IR* drop compensation improves the performance of electrical equipment on these high speed mills in almost every respect which has any influence on the performance of the mill.

There is a certain amount of off-gauge, but this situation is fast coming to the point where it is not much of a factor. By the time the coils are put through the various finishing processes the amount not sheared off is small.

A. I. S. E.

Annual Spring Conference

MONDAY, APRIL 28, 1941

OHIO HOTEL

YOUNGSTOWN, OHIO

MANUFACTURE and COMPOSITION of Grease Lubricants

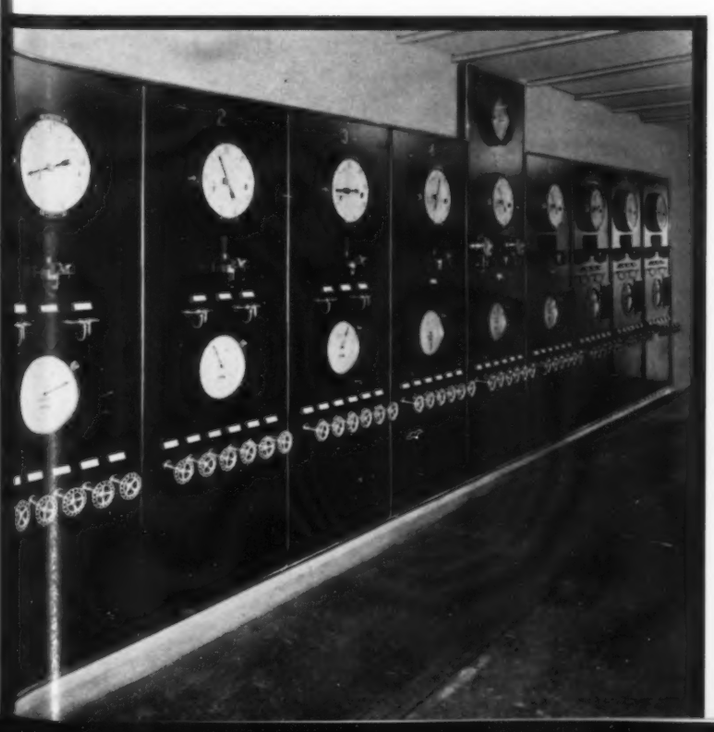
By THOMAS LENNOX, *Manager*
Grease Department, Socony-Vacuum Oil Co., Inc.
Trenton, Michigan

Presented before A. I. S. E. ANNUAL CONVENTION, Chicago, Illinois, Sept. 24-27, 1940

▲ IN tracing the origin of lubricants, authentic data seems to support the contention that solid lubricants were in use for a long time before petroleum oils were known, and early history records that mixtures of animal fats and alkaline substances formed the only materials which were used in eliminating friction when moving heavy objects. These same formulae are the basis of the present day grease lubricants. However, modern research in our industry has been as active and progressive as that in the steel industry, and vastly superior grease lubricants of widely different formulae have been the outcome of such research.

In order to give you a better understanding of our industry's problems in meeting the demand of the steel industry for solid or semi-fluid lubricants, it might be well to introduce the definition and reasons for the use of such lubricants.

Instruments and controls have been widely applied to the modern equipment used in the manufacture of grease lubricants.



The American Society for Testing Materials has tentatively defined a lubricating grease as "A semi-solid or solid combination of a petroleum product and a soap or combination of soaps, with or without fillers, suitable for certain types of lubrication." Wherever mechanically possible, it is still the best operating practice to use straight mineral oils; but in many cases certain limiting factors, such as high temperatures, lack of oil-tight seals, excessive water washing or very dusty atmospheric conditions, preclude the use of liquid products, and where these conditions exist the lubricating grease engineer is consulted. In other words, the lubricating grease engineer is supplementary to the lubricating oil engineer and may be the same person, inasmuch as both forms of lubrication are not competitive with each other.

To give you a better picture of the problems met with in our industry and so acquaint you with its limitations, we will attempt to explain the method of manufacture of lubricating greases in general, discussing briefly the equipment, raw materials, manufacture and composition.

MANUFACTURING EQUIPMENT

Great progress has been made in the use of new equipment for the manufacture of these modern lubricants, and the up-to-date grease works of today is as different from the old ones as the hand-pass mill is different from the modern continuous strip mill. These differences are primarily as follows: The operating personnel in the modern plant of today are technical men with a knowledge of chemical and mechanical engineering, and trained especially for this particular service. The old-fashioned head grease makers have disappeared; and this is very much to be desired, as those I used to know were a cross between a witch doctor and a magician. They tasted and felt the product, and performed so many secret additions of five gallons of this or ten gallons of that, that no two batches were ever alike and

naturally did not perform alike. The equipment of today is just as changed, pressure saponification units having replaced the old open cookers to eliminate any question as to the completeness of the chemical reactions necessary, and positive agitation and mixing in up-to-date designed units insure freedom from undissolved soaps which would cause considerable trouble in modern dispensing systems. To this equipment have been added filtering units as added safeguards to insure exclusion of any foreign material, and the design of the shipping packages has been so changed that no trouble can come from contamination by this source.

It is just as essential to have this modern equipment in our industry as it is to have it in the steel industry, for you all know that poor quality steel can be made from good iron ore, just as poor lubricating grease can be made from first-class raw materials.

Instrumentation of all modern equipment is now complete, and automatic recording units for metering ingredients, temperature control and recording of same are necessary today. The operators of these units, provided with test devices, can control uniformity of quality, and further inspection in modern laboratories is similar to the methods of inspection as adopted by the steel industry.

A description of the equipment in use in the modern grease works today is given briefly as follows:

Pressure kettles are used for the manufacture of the various soaps, and from a construction standpoint are primarily cast or welded steel units, totally closed, heated by steam or oil jackets, and developing internal cooking pressures, depending on the pressure and temperature of the heating medium employed. Most units operate at 75 or 150 lb. internal pressure, thus speeding the time of reaction in the process considerably, and eliminating any guess-work as to the completeness of the chemical reactions. When it is realized that the ingredients which go into the finished product and give it the bodying characteristics are both slightly harmful to machinery in the free state, it is readily understood how important this part of the process is, and I know from sad experience in earlier days how this one change has overcome many of our problems in manufacturing. These units are equipped with double motion agitation and spring steel scraper blades, which clean the sides of the vessels and assist in giving positive mixing and quick heat transfer.

Mixing kettles are of similar construction to the pressure equipment, except that they are open at the top and are equipped for cooling the finished material. They are heated either by steam or oil jackets and have the same type of agitating equipment as the pressure units. The older units did not have such positive mixing and pieces of the cooked soaps could not be completely mixed with the petroleum oil.

Many products have to be cooked at temperatures up to 500 degrees F., the reason for this being to insure the complete elimination of moisture, to produce a certain crystalline structure or to complete certain chemical or physical reactions not possible at lower temperatures. Gas-fired kettles may be used, essentially of the same construction as the steam units, but are heavier in build and naturally equipped with gas burners and ventilating systems for the elimination of fumes. This equipment is also used for chemical reactions such as the combination of sulphur with mineral oil to produce cutting oils, or the union of sulphur or chlorine and saponifiable materials to produce non-corrosive extreme pressure bases for gear lubricants and roller bearing greases.

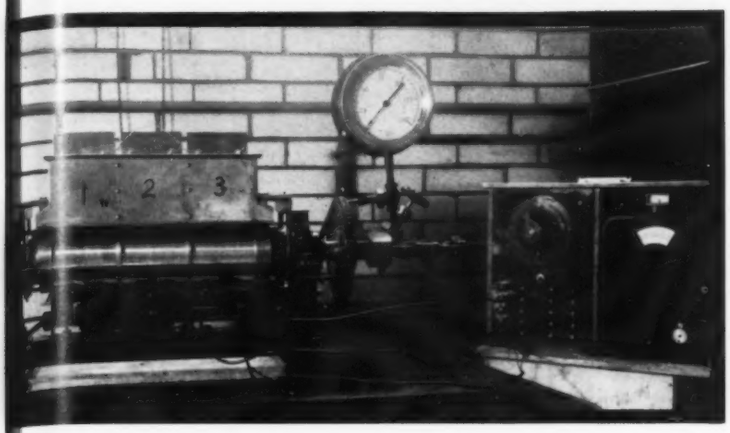
Various other equipment is used, such as grinding mills for making milled greases, dough mixers for mixing wool waste, wool yarn, horsehair, etc., and blocking and cutting machines for various types of block greases. In addition to this equipment the industry has the machinery for the manufacture of so-called cold steel greases whereby, due to the rapidity of the chemical reactions in making these products, two proportioned streams of material are mixed in the pumping operation to form the finished product.

From this approximate list of equipment involved, you can readily see that the modern grease works is in reality a chemical manufacturing plant made up of units for chemical reactions, mixing, drying, filtering, automatic measuring, ventilating, pumping, temperature recording and packaging equipment.

RAW MATERIALS

The raw materials entering into the manufacture of these grease products are many and can be obtained in various qualities, and a description of their properties might be given for your information. Of course, you all know that the products are composed principally of petroleum lubricating oil, but this petroleum lubricating oil can vary from the bottoms left in the still, such as asphalts, up to the finest solvent refined products. Intermediate between these two extremes we have black oils, steam refined stocks, bright stocks, red oils, paraffin oils and neutral oils. These are again broken down into the classes of crude from which they are obtained, and therefore we have all of the aforementioned in the Pennsylvania, Mid-Continent and asphaltic or naphthanic series. Many of these again are subject to different forms of treatment in oil refining, and we can then have solvent treated, dewaxed, acid treated, filtered, etc. All of these are again obtained in different viscosities and are blended together to give us the finished properties of the oil we desire. Inasmuch as these oils are doing most of the lubricating, you can readily see how important it is that their refining and selection be done thoroughly.

The soaps with which the above oils are mixed also have a wide range of properties and many different varieties of material are available in our selection. There are thousands of fatty materials which may be used, all of them with different properties, but the main families of these materials can be classified as vegetable, animal or marine oils. However, that classification has further subdivisions, inasmuch as the fats extracted from the various parts of the plant or body of the animal are entirely different, and even fats from the same animal raised in different sections of this country have different properties, due to different climatic conditions and different feeding. When all of these different fats are subjected to different methods of refining, fat splitting to produce fatty acids, or hydrogenation, you can readily see that a great many combinations are avail-



This block grease tester is typical of the testing machines used for determination of the properties of grease lubricants.

able. The metallic radical of the soap can also be obtained from various qualities of raw materials, as for instance, lime can be used of all different qualities, from ordinary limestone to chemically pure hydrated lime. Naturally, the finely divided, chemically pure material is superior, due to lack of grit and ease of chemical combination. Soda soaps can be made from any caustic material, but are preferably made from pure caustic soda. The litharge used in the manufacture of lead soaps should be resublimed litharge, as this grade leaves no chemically inert material in the form of grit, and the same general teachnique applies to all of the aluminum, zinc or barium salts used for the production of these different soaps.

Other raw materials used embrace talc, or soapstone, in its various stages of fineness, and the same selective care applies to other inert ingredients such as asbestos, pitch, mica, graphite, horsehair, wool yarn, wool waste, waxes, anti-oxidants, etc.

MANUFACTURE

In the manufacturing process we select the proper raw materials mentioned and form first a soap in a pressure kettle. In the manufacture of soda and lime soap products this is done by cooking the proper fat with the soda or lime under pressure for a period varying from thirty minutes to one hour, and this soap when cooked is discharged into a mixing kettle and blended with the proper lubricating oil.

In the manufacture of aluminum or zinc soaps it is first necessary to produce a soda soap. This soap is dissolved in water and the aluminum or zinc soap precipitated by adding the solution of the proper metallic salts, the precipitated soap washed with water many times to eliminate the other salts formed, then dried and blended with the proper lubricating oil.

To manufacture lead soaps, it is necessary to heat the proper fatty material to temperatures exceeding 400 degrees F. and gradually add the litharge at this temperature in small quantities at a time through the use of an electric vibrating dispenser, which controls the rate of feed. After this soap has been heated to higher temperatures, it is then blended with the proper lubricating oil.

In formulations denoting the use of inert ingredients such as graphite, tale, mica, etc., these materials are added after the proper lubricating grease has been made.

That in a general way is the procedure for the manufacture of the majority of these products, although of course many of the minor details encountered in manufacturing would be of interest only to men engaged in the manufacture, and a lengthy discussion in this paper would be entirely out of place.

In all of the manufacturing procedures we are trying to obtain finished products with the following characteristics:

1. Purity (absolute freedom from any ingredients which would cause corrosion, and form gritty material which would produce wear).

2. Uniformity (strict adherence to predetermined standards of purity, consistency, texture, softening point, stability, flow characteristics and lubricating characteristics).

3. Stability (resistance to breakdown and consequent gumming both in storage and in service; resistance to separation and consequent formation of soap deposits both in storage and in service).

4. Suitability to service (ability of each product by virtue of its purity, texture, consistency, structure, softening point, stability, lubricating and flow characteristics to give maximum lubrication and protection in the service for which it is recommended).

COMPOSITION

All grease lubricants are either colloidal or mechanical mixtures of a thickening agent and petroleum oil; but due to the varied local conditions under which the different products must operate, the thickening agents are of widely different character. The first and most common class embraces those made with lime soaps, which due to their water repellent qualities are used very largely in steel mill service. The largest family of this common class comprises the materials sold under the name of cup greases. These are made from a liquid consistency to a very hard solid, and the following chart shows how the penetrations and soap contents range for products using low viscosity oils. Similar charts could be drawn for other grades using still heavier oils.

National Lubricating Grease Institute grade	Percentage of soap	ASTM worked penetration
No. 0	8/10	355/385
No. 1	10/12	310/340
No. 2	12/14	265/295
No. 3	14/16	220/250
No. 4	18/20	175/205
No. 5	24/26	130/160
No. 6	30/32	85/115

Worked penetration means that this will be the hardness after working through the mechanical device which is used in the application. It is good manufacturing prac-

tice to try to keep the difference between the worked and unworked penetrations as small as possible in this particular line of lubricants.

The regular run of high pressure greases are very similar to the cup greases, except that they are blended with higher viscosity oils and show less tendency to separate in service, due to the nature of the oil. This non-separating property can be measured in the laboratory by submitting the products to long-time tests under actual working conditions. The oils in these pressure greases may vary in Saybolt viscosity from 300 seconds at 100 degrees F. to 150 seconds at 210 degrees F., whereas in the cup greases the viscosity of the oil is only 100 seconds at 100 degrees F. Due to the use of anti-friction bearings in large steel mills, it was necessary to incorporate additional materials into these formulae to withstand the heavy loads encountered and still maintain the resistance to washing off by the cooling water used on the bearing. This has been done by the addition to the pressure greases of such elements as sulphur, lead or chlorine, and these are introduced as sulphur combined with saponifiable oils, chlorine combined with paraffin wax or naphthalene, and lead soaps of varying composition. Fundamentally these materials can function in one or more ways. Some of them are known as anti-frictional elements because of their great oiliness; others are known as anti-weld materials because at elevated temperatures the active element combines with the metal to form a film which prevents seizure. This chemical phenomenon can well be explained by the fact known to all metallurgists, that it is impossible to weld steel in the presence of elemental sulphur. Some combinations of these elements, however, will not work satisfactorily, and those which are usually employed must be non-corrosive at ordinary temperatures. Sometimes materials are included in these formulae to act as corrosion buffers, and should the active ingredient liberate its corrosive effect too much, the buffer combines with it to take it out of operation. The development of these products has been of great service to the steel industry over the past ten years, and this is borne out in the fact that anti-friction bearing life has been in many cases six to eight times greater than the manufacturer's original guarantee for such equipment. The development of test machines for measuring this property has been largely due to the research work of the bearing companies themselves, and the majority of the standard methods used for controlling and maintaining the quality of these products has been the outcome of their work.

In this lime soap grease family we also have available a series of heavy greases made with high viscosity residual oils and containing various percentages of graphite. These are used on plain bearings, which are usually flooded with water, and the grease lubricants are applied in block form. We could also say that some of the old-fashioned cold sett greases are in this family, and many of these are still used on cold rolls. These are made up of lime-resin soaps with soapstone as a mineral filler, but their use is gradually dying out due to the introduction of the continuous cold mill.

All of the aforementioned lime soap greases are suitable for bearings where temperatures do not exceed 165 degrees F., where the application is frequent and regular, where churning in the bearing is not excessive, and where a water insoluble product is required.

The next largest group of products comprises those made with soda soap and mineral oil. These products have the same range of consistency as the lime soap products, varying from a liquid state to very hard block greases. Generally speaking, the percentage of soda soap is approximately the same for the consistency designated as that shown under the chart for lime soap greases, and these soaps are also blended with different viscosity oils to produce materials for different uses. However, there is another still greater difference, because while the lime soap greases are all of a smooth, buttery texture, the soda soap greases can vary from this same texture up to very tough and fibrous products. This property is controlled by the nature of the fatty materials used in the soap and the method of manufacture. The ordinary sponge and fibre greases are not satisfactory for many grease lubricated bearings, and products made with much heavier oils, the finished material being put through a grinding process to reduce the fibrous structure, are much more satisfactory. This fibrous structure is due to the length of the soap crystals,

THOMAS LENNOX

and the length is controlled by means similar to the changes which take place in steel on heat treatment and working. A few of the soda soap products are so made that they break down in consistency only within the working parts of the bearing. These greases function so that they fill "the idle space" with fairly stiff grease, while the revolving parts largely eliminate the grease from "the working space," creating a partial cavity. The grease remaining within the moving parts will be small in quantity and through working become fluid. The grease within the housing, but outside the rotating parts, *viz.*, in the "idle space," maintains its original consistency and acts as a seal to keep the soft grease from leaking out, as well as preventing too free a flow of grease into the "working space." With this type of grease in use, small amounts are brushed off and fed into the rotating elements to furnish lubrication and protection. It is obvious that in any ball or roller bearing a reduction in the quantity or consistency of grease

within the "working space" will in turn reduce fluid friction and the torque or power consumed within the bearing. While these products do not comprise a large percentage of the customer's purchases, they are most important, as they are used primarily on electric motors where continuous operation is essential.

Soda soap greases are recommended where operating temperatures are above 165 degrees F., where churning is excessive, where impact or vibration is severe, where the application of the lubricant is not continuous, or where, owing to the presence of water, an emulsifiable lubricant is desired.

Where excessive brinelling effect may be encountered, it is sometimes desirable to add extreme pressure addition agent to these products, similar to the procedure employed with the lime soap greases. In many cases anti-oxidants have been added to prevent deterioration of the grease in bearings which may be subject to long-time standing for extended periods after use, because oxidation would so gum up the metal parts that cleaning of the entire bearing would be necessary before the machinery could be started again.

The aluminum soap greases are still another family, and they vary from a smooth, buttery product to a very rubbery, stringy material. The base soaps are usually very much the same for both types, and the finished product varies according to the mineral oil employed in the blending and the heat treatment to which the product is subjected. Various addition agents may also be used to control the stability of the material or to modify its stringiness properties, depending upon the service for which it is intended. Generally these products are used where operating temperatures are normal, where great adhesiveness is required, where protection from acid effect is necessary, and throw-off or drippage must be avoided.

A small group of greases are still being manufactured in which no soaps are employed as thickening agents, but this solid effect is obtained by the use of mineral filler. Hot neck and mixing greases, for example, are essentially heavy asphalts with soapstone, lime or similar material incorporated, for due to the high temperatures encountered and the method employed in the steel mill for the recovery of the spent product, no soaps are used, and the high melting point of the recovered grease is due to the filler and the oxidation of the asphaltic material.

The composition of gear and pinion lubricants is similar to the hot neck greases, except that the mineral filler in many cases is left out, thereby making the products softer and more adhesive. Sometimes coal tar pitches or fatty acid pitches are used in the formulation of these materials; but due to the fact that the gear lubricant leaks into the bearing, care must be taken in their selection. In certain gear lubricants, mixtures of heavy mineral oil are made with finely powdered asbestos floats, and the percentage of asbestos used controls the final consistency of the lubricant.

Different mixtures of all of the foregoing groups of products can be made to produce certain desired properties, depending on the conditions to be encountered. These same mixtures can be further modified by the addition of horsehair, wool waste, wool yarn, etc. The addition of these materials is to control the application of the product, and has nothing to do with the lubricating value. They are merely used as pads to spread the lubricant or as wick feeds to regulate the consumption. Sometimes these mixtures tend to pack down too hard and thereby cause cut bearings, but if sufficient horsehair has been added, this material will maintain its open state for long periods of time.

Sometimes grease is applied in block form, manufactured from the various products of which we have spoken by increasing the soap content and molding them in machines at high temperatures.

Another very large group of metallic soap products are the leaded gear lubricants, which are used primarily in gear and pinion stands where large quantities of lubricants are in circulation. While these lubricants have been known for a considerable length of time, their composition has been changed to overcome many of the former troubles which were encountered in their use. I have been asked so many times, "Does a lead soap lubricant separate in service?" and my answer must be that when properly formulated it positively will not. The earlier troubles with these products were due to the fact that the lead soaps employed were not soluble in mineral oil at all, and a lead soap of an entirely different nature had to be found. It was discovered that the soaps made from naphthenic acids obtained from petroleum were soluble in most mineral oils used for gear lubrication, and tests on high speed centrifuges proved that these soaps could not be separated from the mineral oil portion. With the introduction of the centrifuge into all of the modern lubricating systems, it was essential that this property should be insisted upon by the consumer. These lubricants are generally used when high unit load pressures are met with, and their adoption has proven their value in eliminating excessive gear scuffing and gear wear. This property is better understood when we can prove by standard methods that these products have a unit film strength six to seven times greater than the mineral oils with which they are manufactured. Other extreme pressure lubricants of different composition are available for similar conditions, but they are only used where the possible entrance of water can be prevented, inasmuch as very stable emulsions may be formed which are hard to separate in the ordinary centrifuge, and these emulsions can in a circulation system develop acidity which may attack some of the bearings.

It is well to point out again that selection of these lubricants can best be made when the composition is known, as local environment plays a great part in determining whether or not they will be suitable for the equipment to be lubricated, due to possible deterioration by oxidation, hydrolysis, bleeding and the catalytic effect of different metals. Methods of application also have a great deal to do with satisfactory performance of any grease lubricant, and our industry has been very enthusiastic about the adoption of automatic lubricating devices by the steel industry.

The cooperation of the lubricating and maintenance engineers has also been of great assistance, and the efforts of these men combined with ours have resulted in lower maintenance costs, lower power consumption, higher tonnage mill production and lowest ultimate lubrication cost. It is the hope of our industry that we will through continued research manufacture grease lubricants with still better resistance to extremes of

temperature, which will through new formulae have greater lubricating efficiency and economy and which will give still higher machine life and greater production on existing equipment.

DISCUSSION

PRESENTED BY

H. H. SHAKELY, *General Master Mechanic,* Hot and Cold Strip Mills, Jones and Laughlin Steel Corporation, Pittsburgh, Pennsylvania.

F. L. GRAY, *Lubrication Engineer,* Carnegie-Illinois Steel Corporation, Gary Works, Gary, Indiana.

THOMAS LENNOX, *Manager,* Grease Department, Socony-Vacuum Oil Company, Inc., Trenton, Michigan.

R. S. SHOEMAKER, *Lubrication Engineer,* American Rolling Mill Company, Middletown, Ohio.

O. L. MAAG, *Lubrication Engineer,* Timken Roller Bearing Company, Canton, Ohio.

E. S. GLAUCH, *Mechanical Engineer,* Joseph Dixon Crucible Company, Jersey City, New Jersey.

HERMAN BERRY, *Assistant Lubrication Engineer,* Carnegie-Illinois Steel Corporation, Gary, Indiana.

H. H. SHAKELY: I know that each and every one of us appreciates the paper by Mr. Lennox. He has covered the field of grease manufacture, both in lime soda soap and leaded compounds. It is a well known fact that many troubles as far as lubrication on different parts of machinery is concerned are due to misapplication. We can't pick any one standard lubricant and use it over any great number of machines. In other words, a grease lubricant must be designed to suit the job.

F. L. GRAY: From the standpoint of the grease manufacturer, how far should we, in the mills, go toward designating the type or the kind of grease we want? You have innumerable combinations of bases and oils, as was pointed out in the paper. Now, if we are ordering a grease, should we go to the extent of specifying the base, the oil viscosity, the method of manufacture; in other words, tell you how to make your grease for the problem we have in the mill? Should we write grease specifications?

THOMAS LENNOX: I would say that would be a hard thing to do, because I don't think you could get enough men in the steel industry who would agree among themselves. About five years ago we had a survey on wheel bearing grease in the automobile industry. You would think that wheel bearing grease would all be the same on passenger cars, but we couldn't find two companies who had the same specifications for a wheel bearing base. That would be the problem in the steel industry. However, we would like to have the advice of the men in the mills.

F. L. GRAY: You would rather receive our problems and design a grease for their solution in your refinery?

THOMAS LENNOX: If the lubrication engineer in the steel mill can give us a picture of what he wants from an operating standpoint, I think it would be better to leave it up to the petroleum industry, inasmuch as our engineering departments compile a complete record of long time performance data on all types of lubricants for all industrial machinery, much of which is similar to that used in steel mills.

R. S. SHOEMAKER: Mr. Lennox says, "It is the hope of our industry that we will, through continued research, manufacture grease lubricants with still better resistance to extremes of temperature, which will, through new formulae, have greater lubricating efficiency and economy, and which will give still higher machine life and greater production on existing equipment."

Let us sincerely hope that his industry will labor long and faithfully and finally bring forth a grease lubricant which will really have a high degree of resistance to extreme high temperatures.

Lubrication for machinery exposed to severe low temperatures seems not to be so much a problem because it is not difficult to obtain semi-fluid greases which operate very well at or around zero temperatures.

It may not be true of all steel plants, but surely many of us have important units which are not satisfactorily lubricated due to unpreventable exposure to excessive heat. It is this condition which causes me to emphasize Mr. Lennox's remarks made at the close of his paper.

While I know of many more, I wish to site two examples which are outstanding from a high temperature standpoint. First, roller bearings on slab heating furnace entrance and delivery tables. This is particularly true where hot slabs are being delivered direct from the slabbing mill. Usually the table rollers are so close to the furnace that heat is absorbed from the furnace as well as from the hot slab. Such tables are subject to reversals and have to support heavily concentrated loads, and are also likely to become warped from hot slabs becoming stalled ahead of the furnace or after their exit on the discharge side. In other words a hard working table plus heat.

The grease manufacturers' recommendation in such cases is usually a soda base grease with various additions or fillers which are not in themselves very effective lubricants. Our experience has been that such filled soda base greases leave a very harmful residue when over heated and will eventually lead to damaged bearings.

After thorough trial of various so called heat-resistant greases in our plant we have started using a cheap lime base cup grease and arranging generous sized relief or overflow connections and then with a power grease gun completely purging the bearings at frequent intervals. The lime base grease residue can in this way be largely removed and the bearing life considerably extended, whereas the residue from special heat resistant soda base grease can only be removed by taking the bearing apart if you get to it soon enough.

This one example is given to show that there certainly is a considerable demand for the development of a grease of the type which Mr. Lennox hopes to develop.

The second example of difficult lubrication due to extreme or excessive heat conditions involves different and much less expensive equipment, but nevertheless it plays a very important part in the continuity of hot

strip mill operations, *i.e.*, the ball bearing equipped rollers of gravity conveyors handling hot coils from hot mill coilers, etc.

The gravity conveyor manufacturer is likely to tell you to use colloidal graphite in some volatile solution as a carrier, or he may tell you to use no lubricant of any kind. I believe these bearings should also be added to the growing list of undernourished or heat prostrated bearings about our plants which are eagerly waiting the successful outcome of further research.

Mr. Lennox's paper gives us some extremely interesting information about the raw materials and equipment used in grease making, and has developed a very clear picture of the exacting procedure necessary to produce the various types of greases required for steel mill lubrication.

However, if the various types are to be intelligently applied in the field, the purchaser must have more complete information about their composition and limitations than is generally supplied.

Trade names and numbers, and the statement that this special grease is about the consistency of number such and such cup grease and has proven very satisfactory for such and such type of machinery, is frequently all the information the grease salesman is able or willing to give us.

This is not altogether true of the major grease manufacturing companies but is too often true of many of the smaller manufacturers.

Many grease salesmen try to get their products started in our plants by sending in sufficient grease for a certain piece of machinery. Suppose it does that particular job very well; we still have no way of judging whether or not it will be safe to try it out at some other location which may be hotter, cooler, dryer, higher or lower in speed.

I believe we will all agree that the only real proof of how well any lubricant will perform is to give it a thorough trial under normal conditions. However, it is my thought that the average grease salesman will do a lot more business if he would let the customer do the experimenting after he had freely supplied enough information about his product so that it could be safely tried out in other locations.

The following minimum specifications should be very helpful:

1. Base—lime, soda or combination.
2. Per cent of soap and of oil.
3. Viscosity of oil used.
4. Nature of filler if any is used.
5. Type of extreme pressure element—lead, sulphur, chlorine, etc.
6. Worked and unworked penetration.
7. Melting point and safe maximum temperature usable.
8. Film strength as indicated on Timken machine or equivalent.

O. L. Maag: A paper such as Mr. Lennox has presented is very valuable to the mill man, in that it removes the mystery so long surrounding the manufacture of lubricants. It gives him fundamental data about compositions of lubricants he is using. He can often use this knowledge to advantage in various mill applications and is thus able to solve minor problems in lubrication about the mill without calling in outside help.

By the free exchange of ideas between the lubrication engineers and the designing engineers, many difficult lubricating applications have been eliminated. This exchange of information has been valuable to all parties concerned, and has been the forerunner of the high speed mills of today. There, however, is still need for more improvements. The big enemy to many lubrication problems is still water, scale, etc. We must look forward to improvements in guards, closures, etc., to keep these materials from getting into the mill lubricants. Many of the ideas for eliminating these troubles will come from operating men, and they should be encouraged to offer suggestions. It is very generally agreed that fluid lubricants are more efficient than heavy ones, so naturally the trend should be toward mill designs, where the more fluid products can be satisfactorily used. Enclosed gear boxes, now lubricated with fluid oils is an outstanding example, that has made possible a change from a heavy, tacky, inefficient lubricant to a more economical and efficient product. With many of the present high speed gear units, it would be impossible to use open gears and heavy greases in that centrifugal force would throw off the lubricant; whereas, with the enclosed housings high efficiency is obtained with fluid oils constantly supplied from a bath or from a centralized circulating system.

There is very general agreement that the quality and stability of lubricants furnished the mill man today is above those of fifteen years ago, brought about by research and better methods of manufacture. The author mentions that they are trying to manufacture lubricants of high degree of purity, and free from corrosive, and gritty, abrasive materials.

We feel they are right in steering clear of products containing free inorganic substances which are all more or less abrasive. There is some excuse for the use of inorganic fillers for a run-in period to smooth up bearing surfaces, but after that is accomplished, nothing but clean, 100 per cent lubricant should be used. If loads and speeds are such that galling or scoring results on run-in and properly aligned bearings, it will be necessary to use a properly compounded lubricant of the extreme pressure type.

The author tells you of the soda soap greases that are made heavy enough to help form seals for antifriction bearings and in the operating zones thin out for proper bearing lubrication. These features are fine, but must be properly controlled. The grease must not be too heavy that it will not feed into the bearing areas when needed under all operating temperatures, also the grease must not work down too much and become too soupy, so that it works out by closures.

The leaded and other extreme pressure gear lubricants discussed by the author have, as a whole, done an outstanding job. They are better compounded today than ever, and in our experience, where troubles of separation have occurred, it has been caused by the entrance of foreign matter into the unit. These products, however, should all be checked by the users to see that they are non-corrosive, stable and uniform as received. Since they are all compounded products, it is

very essential that all precautions necessary be taken to prevent the entrance of any foreign matter.

The author has presented a chart adopted by the National Lubricating Grease Institute covering the various grades of greases. This chart, if put into general use by both makers and users of lubricants, will eliminate much confusion and both makers and users of lubricants will benefit. May I suggest that you mill men use the numbers listed there in ordering greases with the specified penetrations. Such a standardization is certainly a step in the right direction, particularly if the national emergency appearing on the horizon actually presents itself. Since the National Grease Institute has given us the standard we owe it to them to do our part to establish and put it into common use.

H. H. SHAKELY: I think each one of us connected with the mechanical end of the steel mill will agree with Mr. Maag in his statement that much can still be done as far as the tightness of a bearing is concerned; in other words, keeping out the foreign bodies, dirt, scale and especially water, with which we are troubled more than anything else on a hot strip mill. In fact, when we first started at Pittsburgh, we were in trouble for quite some time. It has taken quite a bit of development work, both on oil seals, and on the actual sealing of the chucks, to eliminate our trouble. It is common now to run from eight to ten days with a water content of one-half to one per cent. This is with an oil bearing. If we could get the same thing in grease bearings, I think many of the troubles of the user and the manufacturer of the grease would be eliminated.

E. S. GLAUCH: Regarding the question asked by Mr. Gray, we have had considerable experience with specifications on lubricants, and personally, I hope the mill lubricating engineer does not start to draw up grease specifications. The final outcome would be that the purchasing department would take those specifications and start shopping, and within a year or two, the greases you would get would not resemble the greases you were getting when you specified that particular grease. In other words, we have bid on grease and find that we meet the specifications and give the customer exactly what they want. Sooner or later some company starts to substitute to get the price down in order to get the business. I am referring mainly to government business where they endeavor to buy on specification, and what is stated above has happened. That is all I have to say on that point.

In connection with the discussion by Mr. Shoemaker on high temperatures, to the best of my knowledge, I know my company does not have grease to meet the temperatures where they go to 500–600 degrees F. Whether or not other companies have, I don't know, but doubt it. We have found that some people, after they have run into conditions of that type, come to us, and when they do come, our recommendation generally is powdered graphite, and no oil. If oil was used with the graphite, sooner or later carbonization of the oil sets in and it will form a hard substance which prevents proper lubrication. We have had such situations on tunnel kilns and soaking pit bearings. In cases of that type, we have found that graphite has done better work than thousands of pounds of grease, because the grease did not do the work, but clogged the bearings and eventually they had to be chiseled out.

There was one large company which operates tunnel kilns, and they tried a method somewhat similar to what Mr. Shoemaker suggested of purging the bearings. Instead of doing that exactly, they cut a hole in the bottom of the bearing housing. They figured that when the car got to the middle of the kiln, the rotation of the roller bearing would dump everything out at the bottom. Even that didn't work, and we suggested they use graphite. They used it and it has worked fine. Then the problem was to get the dry graphite into the bearing with the minimum of labor. Today they are using water as the vehicle. They lubricate the bearing just before the car goes into the kiln, and as soon as it hits the hot zone, the water is driven off and the factor of corrosion is eliminated. There are other concerns using the same type of equipment that use kerosene, or some light volatile liquid to get the graphite into the bearing.

One steel manufacturer, on soaking pit covers, used thousands of pounds of grease, and still he was in trouble. Our man recommended a little graphite, and the result was that I think about 10 or 15 lb. of graphite a month has taken the place of several thousand pounds of grease, and the bearings do rotate where formerly they would become clogged and the wheels would slide, and then they had to clean out the bearings.

HERMAN BERRY: Regarding Mr. Lennox's discussion on the use of various lubricants, machinery manufacturers frequently call upon several petroleum companies for their recommendations of lubricants for new equipment.

In most cases the recommendations are by brand name only. Such practice is of little value to mill lubrication engineers, who are responsible, in most cases, for approving and selecting the lubricants for use on new installations. In some instances misinterpretation of brand names by representatives of machinery manufacturing companies has caused confusion, and the initial use of the wrong lubricant.

It would be helpful to us if the machinery manufacturers would require all petroleum companies who furnish their recommendations to also furnish a typical specification, in addition to brand names, of all lubricants recommended. Such specifications should include: for oil—viscosity at 100 degrees F. and 210 degrees F., flash point, pour point, and presence of any compounding; for grease—soap base, worked penetration and oil characteristics.

H. H. SHAKELY: I agree with your statement along those lines, but I feel even if you buy a new piece of equipment and it comes in with a brand name lubricant, it is still the duty of the lubrication engineer, or the master mechanic, to whom the duty falls to maintain the machinery, to decide if it is right or not. I think the practice of putting on trade names is wrong, but we still have the right to get the lubricant we want to use.

SECTION ACTIVITIES

BIRMINGHAM DISTRICT SECTION

FEBRUARY 24, 1941

"Engineering Research and Design of Motors for the Steel Industry," by A. M. MacCutcheon, *Vice-President and Chief Engineer*, Reliance Electric and Engineering Company, Cleveland, Ohio.

MARCH 24, 1941

"Rolls and Roll Design," by Clifford Elms, *Chief Engineer*, Pittsburgh Rolls Division, Blaw-Knox Company, Pittsburgh, Pennsylvania.

CHICAGO DISTRICT SECTION

MARCH 11, 1941

"Recent Developments in Mercury Arc Rectifiers," by W. E. Gutzwiller, Electrical Department, Allis-Chalmers Manufacturing Company, Milwaukee, Wisconsin.

CLEVELAND DISTRICT SECTION

MARCH 10, 1941 (Youngstown, Ohio)

MARCH 12, 1941 (Cleveland, Ohio)

"Induction Heating and Hardening," by W. E. Benninghoff, *Division Manager*, Ohio Crankshaft Company, Cleveland, Ohio.

DETROIT DISTRICT SECTION

MARCH 11, 1941

"Sintering of Ore," by E. W. Shallock, *Chief Engineer*, American Ore Reclamation Company, Chicago, Illinois.

PHILADELPHIA DISTRICT SECTION

MARCH 1, 1941

"The Design of Lubricants for Mechanized Lubrication in the Steel Industry," by F. E. Rosenstiehl, Technical Staff, Texas Company, New York, New York.

APRIL 5, 1941

Maintenance Symposium: to be presented by W. H. Burr, F. O. Schnure, A. T. Halstead, and F. C. Schoen.

PITTSBURGH DISTRICT SECTION

FEBRUARY 24, 1941

"Induction Heating," by H. E. Somes, *Chief Engineer*, Budd Induction Heating, Inc., Detroit, Michigan, and C. C. Levy, *Induction Heating Engineer*, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania.

MARCH 24, 1941

Symposium: "Application and Maintenance of Steel Mill Auxiliary Bearings."

Blast Furnace Rehabilitation

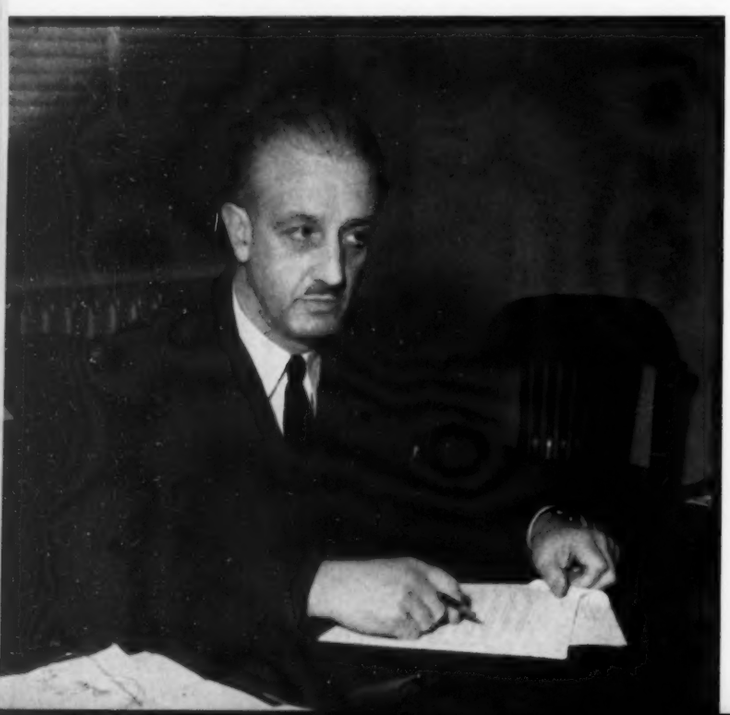
By J. H. SLATER,
Assistant District Manager
Republic Steel Corporation
Cleveland, Ohio

Presented before A. I. S. E. ANNUAL CONVENTION, Chicago, Illinois, September 24-27, 1940

▲ THE rehabilitation of blast furnaces has become of paramount importance in recent years. It is especially important at the present time because of the marked shortage of scrap materials. Iron and steel scrap has steadily moved to foreign ports during the past few years, although this movement has now been stopped by the recently enacted embargo on such materials. Today our national safety rests upon our ability to produce iron and steel in sufficient quantity to meet the demands of re-arming the nation rapidly. A shortage of scrap places a much heavier load on our blast and open hearth furnaces.

The problem of rebuilding a blast furnace is always an interesting one. In times of high operating schedules, an important consideration is how much can the furnace capacity be increased without undue loss of time between blow-out and blow-in. Quite frequently conditions are such that an efficient organization can expedite the work of construction so that very little extra time is required over what would be necessary for a first-class replacement. In fact, furnaces that do not lend themselves to some enlargement and improvement are rather exceptional. To rebuild a furnace to previous lines, without considering all the possibilities of obtaining even a nominal increase in tonnage or efficiency, should be looked upon with disfavor.

J. H. SLATER



FOUNDATIONS

One of the most important considerations in any enlargement program is foundations. Most old furnaces were built on wooden piles. Even where they were capped below water line, heat transmitted through the concrete has deteriorated the top portion of such piles and rendered them unfit for re-use. Any fluctuation or change in the level of ground water also has a damaging effect on such piling. To support a modern 1000 ton furnace requires sufficient piling to carry a 16,000 to 18,000 ton load concentrated in about a 70 ft. square ground area. It is virtually impossible to get enough wooden piling in such a restricted area.

Where rock strata is within about 80 ft. of the surface, steel pipe driven open end to bearing on rock makes a substantial as well as economical foundation. Pipe used in this manner drives easily. After reaching rock the inside of the pipe is cleaned out by blowing with air and is then filled with concrete. A furnace resting on such a foundation cannot settle under any conditions short of a serious earthquake.

FURNACE DESIGN

In any rebuilding program the question of the design to be adapted to the existing conditions comes in for careful consideration. The elements entering into the design of an efficient blast furnace have resolved themselves into quite generally accepted standards.

The crucible or hearth section has become fairly uniform in dimensions. For instance, the depth of the hearth below the center line of the tuyeres varies from 7 ft. on a 10 ft. diameter furnace, to 10 ft. 3 in. on the 26 ft. diameter furnace. The vertical distance from center line of iron notch to cinder notch is within close limits the same for all furnaces. This also applies to the vertical distance between cinder notch and tuyeres.

Methods of hearth cooling and type of construction have become generally accepted on all recent large furnaces to be a cast iron stave jacket with pipe hairpin coils cast in. More attention is being given to the closer spacing of these hairpins for adequate cooling. These staves are retained by a solid steel plate jacket.

Bosh height varies from 9 ft. to about 14 ft., the majority of furnaces being within the 10 to 12 ft. range. The bosh area, in reference to the hearth area, varies from around 106 to 180 per cent, while the majority of the furnaces fall within the 120 to 130 per cent range.

Bosh construction has been generally of the band type with copper cooling plates spaced uniformly in a circle between the steel bosh bands. Particular care is taken to provide a generous amount of cooling around the tuyere zone, the amount of cooling being gradually decreased as the distance from the tuyeres increases.

The inwall batter is generally under 1 in. per ft., with the majority of furnace inwalls between ¾ and 1 in. Inwall cooling is done with flat copper plates built into the brick work, cast iron plates having largely disappeared. One furnace which has operated successfully for years has steel pipes placed for a vertical distance of 18 ft. above the mantle. These pipes are spaced fairly close to the shell and have given satisfactory service.

Stock line diameters are being kept as large as possible within the practical limitations imposed by inwall batter and bosh diameter. Stock line armor is generally being built as individual plates bolted together to make a complete circle. The plates are cast of carbon steel and are carried on brackets which permit movement with any expansion of brick work.

ALTERING THE FURNACE

Often it is possible to increase the hearth diameter of an existing furnace as much as one foot without entailing a great deal of expense. However, the maximum benefit from such an increase is not realized unless it is accompanied by a corresponding increase in furnace volume. Such increases can be realized cheaply only where the old furnaces have been generously designed.

Most furnaces have columns set on a batter which permits the hearth jacket to be brought out to the inside edge of the column base plates.

With all the enlargement possible taken at the hearth jacket, the next stricture occurs at the mantle. This is really the bottleneck of any enlargement program. Bosh angles are generally accepted today to be 80 to 83½ degrees and unless the mantle section of an old furnace had been provided with a generous width of brickwork, a simple enlargement is out of the question. Then if other conditions warrant, a new mantle with some new shell work must be considered.

Again, if all other conditions are favorable, a new set of columns and mantle may be erected around the existing furnace and the new shell attached to the existing shell, after which the old shell, mantle and columns are removed.

Increasing furnace capacity does not always involve changing the hearth area. This was the case in a furnace which came up for relining that already had a large hearth diameter. Analysis indicated that the working volume supplying this hearth was small; in fact, it was about the same as found on furnaces whose hearth area was 25 per cent smaller. In this instance, it was clear that the most economical increase in capacity would come from increasing the working volume. This was accomplished by increasing the bosh diameter and raising the height of the furnace stack, which resulted in a balanced design with adequate working volume that properly prepared the material for the tuyere zone. The working volume was increased 33 per cent. The added furnace height permits longer time contact in the furnace, resulting in lower top temperatures.

View of the largest blast furnace in the world, a typical example of modern rehabilitation.

The lower the temperature at which gases leave the stock, the lower the velocity, with a correspondingly lower dust carrying capacity. This results in lower velocity in the uptake and downcomer system, thus providing for more effective dust removal.

The greatly increased furnace volume has resulted in a lower coke rate and less loss from the production of flue dust. The lower flue dust content of the gas has made it possible to retain old dust catchers. In fact, the dust catcher became more effective and in turn placed a lighter load on the primary gas washer, even though more gas is being cleaned. This balanced furnace design resulted in a more efficient operation and the effects were far reaching.

With approximately the same amount of coke consumed per day as under the old design, it became possible to produce better than 10 per cent more iron. With the same amount of coke burned, the wind requirements remained about the same. The gas production, which is a function of the wind blown, entailed no changes in gas cleaning capacity, nor was any increase to blowing equipment necessary. The advantages multiplied through each phase of the operation, and were altogether gratifying.

Since the blowing equipment did have a slight surplus in capacity, this could be used to produce still more iron. This extra blowing capacity was not used under the old design, because the ability to consume additional coke was lacking. The previous design used better than 1925 lb. of coke per ton of iron produced, while the new design called for only 1850 lb. of coke. This meant that for every ton of iron previously produced, 75 lb. of coke could be utilized to produce more iron.

A comparison of the results obtained with the old and new furnace will illustrate the improvement effected by the changes in design.

	Previous design	*New design*
Wind blown, cu. ft. per min.	70,000	80,000
Tons of iron per day	950	1,125
Lb. of coke per ton of iron	1,925	1,838
Lb. dust produced per ton of iron	250	153

Another furnace rebuilt early this year was greatly improved by providing 16 tuyeres instead of the original 12 tuyeres. In other respects the furnace was left much the same. It is interesting to note the difference in performance brought about by this change.

	Before changing	*After changing*
Wind blown cu. ft. per min.	67,000	65,000
Tons of iron per day	921	1,003
Lb. of coke per ton of iron	1,960	1,762
Lb. dust produced per ton of iron	230	160

The old furnace had burned many tuyeres and had always worked poorly. The new design is working satisfactorily.

HANDLING OF STOCK AND COKE

Another phase of rehabilitating old furnace plants meeting with increasing attention is stock and coke handling. Recent trends have been toward ample screening of the braize from the coke just before charging into the skip buckets. Present stationary screens or rotary grizzlies are being replaced by mechanical shaking screens.

Nut coke is charged as a separate unit of the round. Usually nut coke is carried in the stock bins and charged through the scale car.

Furnace coke is fed from the bin over a screen, which acts in the dual capacity of screen and feeder. When the desired weight is reached, the screen is automatically stopped. The weigh hopper is automatically discharged into the skip bucket in predetermined parts of the round. After the weigh hopper is emptied, a zero weight impulse received from the scale closes the gate. The hopper is then ready to receive another unit of coke, which it does immediately after the skip bucket automatically starts for the furnace top with its load of coke.

Thus all the coke is handled from bin to furnace without any help from the scale car operator, whose entire attention is directed to the drawing and charging of ore.

A further interlock prevents the accidental discharge of ore simultaneously with the discharge of the weigh hopper. This is accomplished by locking out the air valve to the scale car discharge gates.

Provision is made also to charge coke automatically by volume instead of weight.

SKIPS

The speed of travel of skip cars must be considered in any rehabilitation program.

Excessive speeds are seldom required. Free running speeds between 300 and 400 ft. are usually ample to fill most furnaces, with enough surplus capacity to catch up with the furnace on delays.

A few furnaces have been provided with free running skip speeds up to 600 ft. per min. Such speeds are rarely required. Due to the short travel of the skip cars from pit to furnace top, usually under 190 ft., it is apparent that fast speeds can reduce the total time of skip travel only a few seconds.

The distance left for free running speed, after deducting the accelerating and decelerating distances is not great enough to weigh very heavily in point of time between say 400 and 600 ft. per min. The horsepower requirements for an occasional need for 600 ft. per min. cannot be justified economically.

Higher speeds require larger cables and entail increased wear on skip cars and hoisting equipment. In addition, the distributor, bells and scale car must be made to move faster so that a skip waiting period does not occur. Usually the stock house is the slowest part of the filling operation and to match a 600 ft. skip speed the scale car speeds would increase beyond the safe maintenance level.

Of course all of the above is based on a two bucket charging system. With a single skip bucket, conditions are considerably altered and fast speeds are necessary unless a very large skip bucket is used. Buckets of 200 cu. ft. capacity have become almost standard size for the large furnaces.

INSTRUMENTS

The tendency has been toward providing the operator with more information regarding the process, with the thought that the more intimate his understanding of all phases, obtaining at any given time, the better able he is to produce a superior product at a lower cost.

Meters are provided which enable the operator to know how much wind is being blown, how much gas is going to the stoves, the temperature and pressure of the gas leaving the top of the furnace, and the pressure of the cooling water going to the furnace. Automatically controlling the temperature of the wind to the furnace permits a constant and uniform input of heat into the burden.

On the "must list" of any furnace rehabilitation, should be a stockline recorder which makes a continuous printed record of the level at which the stock is carried and also showing the rate at which the furnace is driving.

More attention is being given the centralization of instruments for the convenience of the operator. In several recent installations, the controls for the mud gun are placed in a separate room especially located to provide the operator ample safety when operating the mud gun. This room is also used to house all operating gauges and instruments. Great care is taken to select materials of construction that are readily kept clean, thus enabling the operator to take justifiable pride in his surroundings.

STOVES AND GAS CLEANING

Stove shells of all welded construction are meeting with favor. With this type of construction, inside surfaces of the shells are perfectly smooth and do not require the chipping and cutting of insulation around rivets and seams.

Much can be done toward effecting economies by carefully studying any shortage of stove capacity and eliminating any deficiency by adding inserts or fillers. In cases where existing brickwork does not justify this method, the rebuilding of the stoves with small checkers meets with favor.

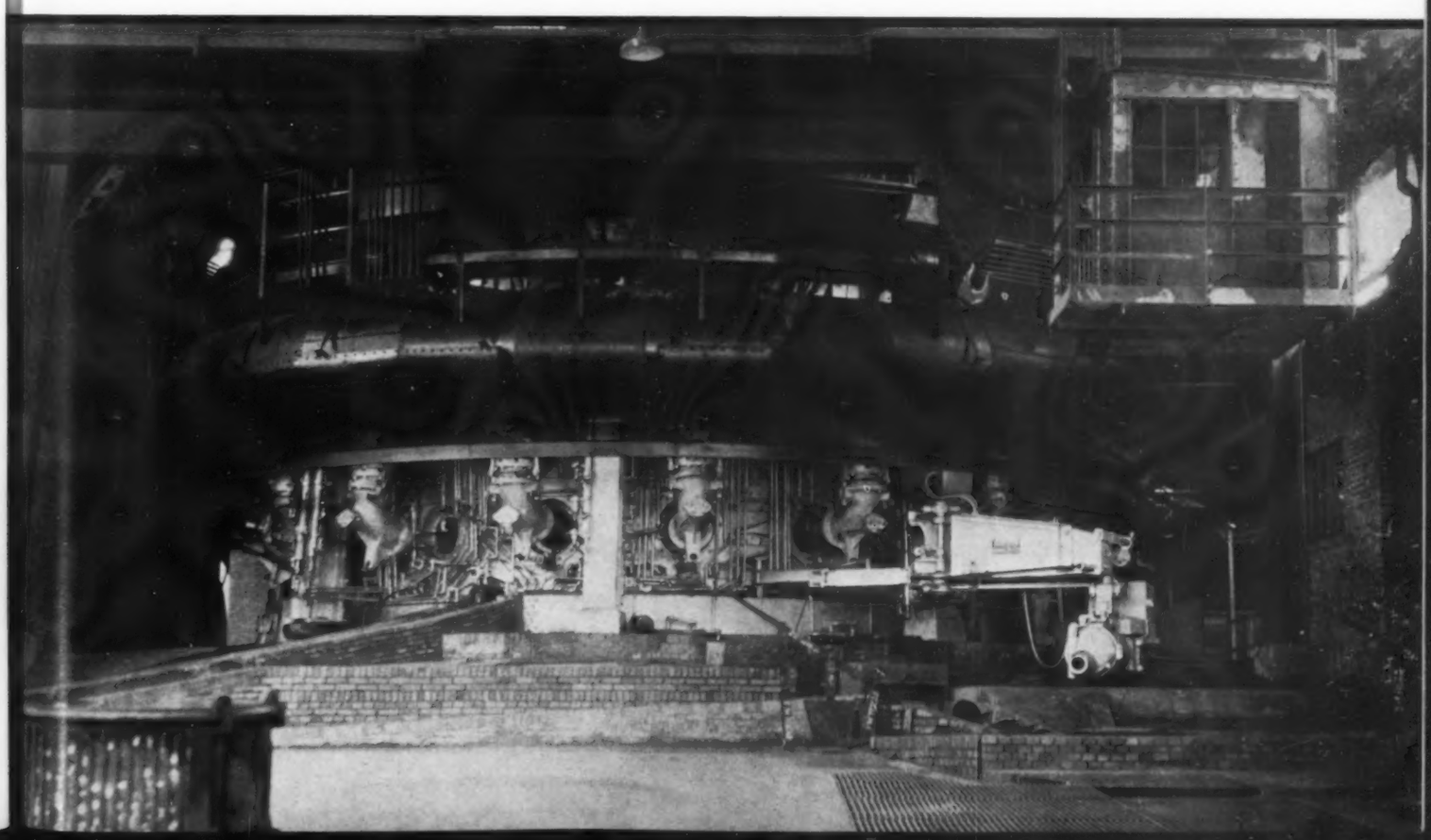
Plants able to utilize all their blast furnace gas are realizing dividends from adequate insulation of stoves and blast mains.

Rehabilitating a furnace plant often reveals that the gas mains are large enough to handle quite an increase in gas quantity. Usually the hot blast mains, hot blast valves and bustle pipe are too small to handle a greater volume of air efficiently.

Another deficiency usually is found in the size of the by-pass line tempering the hot blast to the furnace. By-pass lines have been invariably too small to control the temperature when a stove is first put on the furnace.

Mechanism for regulating the amount of cold air entering the hot blast main has undergone considerable improvement. Temperatures are quickly brought to desired and preset values and held within close limits. The control manufacturers have carried on considerable research work to perfect equipment which responds readily. Of course, such equipment cannot function unless the by-pass line is sufficient in size to permit an inrush of a sufficient volume of cold air to temper the effect of a fresh hot stove being put on the furnace.

It is also futile to expect any mechanism to do an effective job of control unless the by-pass line has a



Modernized blast furnaces usually show increased hearth diameters, and in the larger furnaces sixteen tuyeres are often used.

valve that can be moved from open to closed position quickly.

Reducing the checker openings with fillers or installing smaller checkers requires use of clean gas, cleaned down to .02 or .025 grains per cu. ft.

At the present time, the industry has become clean gas conscious. Many plants today are examining their gas cleaning equipment with the thought that more efficient cleaning of gas will pay dividends.

Small wet primary washers are in use today which clean the large quantity of gas from a 1000 ton furnace to under .2 grains of dust per cu. ft. of gas. Such cleaning was not previously obtained except with units of large size.

This cleaning places a lighter load upon the fine cleaning equipment.

There are in service today stationary wet washers which fine clean gas to 0.1 grains per cu. ft. Such cleanliness is ample for boilers and all but the small checkered stoves. For the 2 in. by 2 in. checkers, gas cleaned to .01 grains per cu. ft. is required. Such cleanliness is obtained with electric precipitators, wet disintegrators having generally given way to electrical precipitation, principally because of power required.

Modern burners of the pressure type are being used for stoves. These, of course, function better with fine cleaned gas.

A fine cleaned gas supply to the stoves is in some localities cleaner than the air used for combustion. It is possible that in the future air cleaning for combustion will go hand in hand in gas cleaning.

Cold blast conditioning is being considered at a number of plants. The installation at a southern plant for controlling the amount of moisture in the blast has met with success.

The foregoing is an outline of some of the factors involved in rehabilitating a blast furnace. An enlargement program frequently entails also problems of additional blowing equipment, changes to the trestle to permit handling of the additional stock, and sometimes also the problem of greater coke production. When tonnage is urgently needed, there will generally be hesitancy and delay in undertaking such a program. It is well therefore to plan the improvement for a period when the loss of production will not seriously interfere with operating schedule.

DISCUSSION

PRESENTED BY

HJALMAR JOHNSON, *Superintendent of Blast Furnaces,* Inland Steel Company, Indiana Harbor, Indiana.

J. H. SLATER, *Assistant District Manager,* Republic Steel Corporation, Cleveland, Ohio.

C. H. GLASER, *Superintendent of Blast Furnaces,* Carnegie-Illinois Steel Corporation, Youngstown, Ohio.

G. T. WILLIAMS, *Superintendent,* Blast Furnaces and Coke Plant, Youngstown Sheet and Tube Company, Indiana Harbor, Indiana.

A. W. VINCENT, *Assistant Superintendent,* Blast Furnaces, Carnegie-Illinois Steel Corporation, Gary, Indiana.

R. A. LINDGREN, *Superintendent,* Blast Furnaces, Wisconsin Steel Works, International Harvester Company, Chicago, Illinois.

C. P. BETZ, *Assistant Manager,* Hanna Furnace Division, Great Lakes Steel Corporation, Ecorse, Michigan.

HJALMAR JOHNSON: I was very much pleased to hear this paper because Mr. Slater covered the field thoroughly. He has had a great deal of experience, and I can appreciate the problems he has gone through on this rebuilding program.

I was particularly interested in the figures he quoted on this one furnace, where they went from 12 to 16 tuyeres, and made a very astonishing increase in production and decrease in coke rate. Can it be assumed that all other factors were identical, so that the only change was the number of tuyeres? Might there have been other incidentals?

J. H. SLATER: For years that furnace has been very obstreperous. We had a great deal of trouble with it. It was burning an excessive amount of copper, and we hadn't been able to do anything to correct this condition. We thought for a while there was a kink in the hot blast main that was causing our trouble, and that the furnace was getting more wind on one side than on the other.

About two years ago we blew the furnace out because of market conditions. I went in, and in between the tuyeres, there were pilasters built up along the bosh. My idea was that the tuyeres were spaced too far apart. We changed that, and the only other change was that we changed the bosh angle from 86 to 83 degrees. That may have had something to do with it, but in my opinion the big change in the operation of this furnace was increasing the number of the tuyeres. Since blowing in on 16 tuyeres, the furnace has operated perfectly. The iron has been good. We have had no trouble with it at all, and it is an altogether different operating furnace.

C. H. GLASER: We had pretty much a similar experience. We had two furnaces, one a 23 ft. 6 in. furnace, built in 1932, which we had put in blast and were never able to get the tonnage per sq. ft. of hearth area we should get. So in 1937 we had another furnace relined, which was built to a 23 ft. hearth. Using the same reasons Mr. Slater gave, we put 16 tuyeres in this new furnace, and today it will make more tonnage than the 23 ft. 6 in. furnace. The only difference between the two furnaces is 6 in. difference in the hearth and 6 in. difference in the stock line.

We built a 25 ft. furnace in 1928, and we are probably one of the few plants that still believe in single skips. At that time, some questions came up as to whether we could fill the furnace with a single skip, the speed required for our skips, and the size of our skips. We tried to do the job without making any major changes in our stock house, which, of course, originally was for

a 500-ton furnace. We were able to enlarge our skips to about 175 cu. ft., and we run a skip 750 ft. per min. That is the furnace that we patched once, and on which we made over three million tons.

On one that we rebuilt we made no changes at all. It had 16 tuyeres, with a 25 ft. hearth. We did put in a new coke screen, and for the first two months it has been in operation, it has been averaging about 1500 lb. of coke, making bessemer iron.

I certainly agree with Mr. Slater that we need 16 tuyeres in any furnace above 18 ft. Along with that new furnace we rebuilt two stoves, new shells which were welded steel construction, and 2 in. checkers, each stove having 187,000 sq. ft. We were able to run those stoves at 250 to 300 degrees stack temperature.

G. T. WILLIAMS: We have a 22 ft. furnace that was built in 1925 with 16 tuyeres. I had nothing to do with it any of that time. I don't remember that I ever was there when it was running, but at the end of one campaign they changed that from 16 tuyeres to 12, and it has been a much better furnace for it.

ALBERT W. VINCENT: I have had no recent experience in the rehabilitation of furnaces, but this conversation concerning 16 tuyeres is most interesting. I have never had any experience on a furnace that had more or less than 12 tuyeres.

The condition Mr. Slater spoke of—of the pilaster built between the tuyeres—I saw that quite a number of years ago on a small furnace that had only an 18 ft. 6 in. hearth, and it was quite pronounced. We never could satisfy ourselves as to the cause of it. Mr. Slater may have the solution of that problem in more tuyeres. Any discussion I might offer would be based entirely upon assumption, therefore of little value.

J. H. SLATER: I only know that this furnace was in blast—she made one and one-half million tons—and it was tough going all the way. It never was a properly working furnace. Somebody had the idea there was a kink in the hot blast main. We shut down for three or four days, and spent a lot of money to correct this condition, but could see no improvement. We had periodic sloughing off, burning of tuyeres, burning of copper all the time, and we couldn't correct it.

On this last rebuild we put in 16 tuyeres, and it now is a real operating furnace. Possibly the materials we are using are different, but for our purposes that certainly has corrected it. It is a real furnace now.

The question was asked, what other things were done? There has been nothing done, except to change the bosh angle from 86 to 83. Outside of that, it is just the same furnace that it was before, and it never was right before.

R. A. LINDGREN: Perhaps this furnace that the pilasters were found on was badly overblown.

J. H. SLATER: On the furnace in question we had a 24 ft. 6 in. hearth diameter, and we blew 68,000 cu. ft. of wind per min. What do you think about it?

R. A. LINDGREN: What is the ratio between tuyere area and volume of wind blown?

J. H. SLATER: We tried everything. I have always adhered pretty much to the practice I got from Mr. George Williams out here in Chicago, *i.e.*, 6.75 sq. in. of tuyere area per 1000 cu. ft. of wind blown. I got that from Mr. Williams back in 1932 or 1933, and I have stuck to it all the way through. The big furnace in Warren is a 27 ft. hearth. I have had her down to 18,000 ft. of wind, making as little as 275 tons a day on 3 in. tuyeres, and have followed this tuyere area all the way through. I don't think we overblow it at all. I think our tuyeres were spaced too far away for the material we used. Maybe it isn't right for your furnace, but it is right for ours. When you have these pilasters built up between your tuyeres, and you get these sloughing off periods every two or three days, I am satisfied we know the answer for our condition; I don't know what it is for yours.

C. P. BETZ: Has anybody any suggestions as to how high we should go with a furnace? What height will give us the most efficient operation on a 25 ft. hearth furnace?

HJALMAR JOHNSON: We built our 25 ft. furnace 101 ft. high, and we have had no indication that it is too high. There is reason to believe that more might be gained by building it still higher.

J. H. SLATER: We have one furnace 105 ft. high and another 106 ft. high. As Mr. Johnson says, we have every indication that we have improved our coke practice, and are getting benefit from it. We are going to wait for the rest of you fellows to do something beyond 106 ft.

C. P. BETZ: Where is the proper location for the mixer valve? Should it be placed at the extreme end of the hot blast main, between the stoves and the furnace, or should we install the Vincent type mixer connection?

HJALMAR JOHNSON: We have a Vincent type mixer on four of our five furnaces. In this system, the cold air is introduced into the bottom of the hot blast valve drum, so there is an individual line for each individual stove from the main mixer line. On those stoves which are equipped with a gate valve, it is more difficult to get a good mechanical job, and for that reason we have not installed it on the one furnace which has this type of hot blast valves. We are very much satisfied that this mixer arrangement is far superior to either mixing in the end of the main or at any intermediate point.

C. P. BETZ: We have experienced trouble with brick failure in the hot blast main where the mixer valve is located at the end of the hot blast main.

We changed the connection on this furnace to a point between No. 1 and 2 stoves and have not had any brick failures since nor have we experienced any difficulties due to poor mixing of cold with hot blast.

J. H. SLATER: I have experimented with that considerably. I find that introducing your cold air at the end of the main gives you a much better mixture of air, gives you much better life on your hot main, and much less variation from one tuyere to another, compared with introducing it close to the furnace. That is the reason I have gone to that.

DESIGN AND OPERATION
Continuous Buttweld Pipe Mills

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▲ ONE hundred and fifteen years ago, back in 1825, Cornelius Whitehouse drew a white-hot flat strip of metal through a forming die and first succeeded in making buttwelded pipe. This was the beginning of what is commonly known as the conventional buttweld process by which flat skelp is both formed and welded into pipe in one operation.

In 1911, John Moon began experimenting with the idea that a mill could be developed to buttweld pipe continuously. After spending considerable time discussing with Stewarts and Lloyds in England the operation and construction of conventional buttweld mills, Mr. Moon made plans to build the first continuous mill.

S. F. Fretz, Jr., who later became a partner in the Fretz-Moon Tube Company, undertook the work with John Moon. This first mill, including the furnace, cost $525.00, and its maximum pipe size was ⅛ in. The forming rolls were 3 in. in diameter and the heating furnace, which was only 10 ft. long, was fired by one oil burner.

This home-made piece of equipment proved so very successful that in 1921 and 1922 the Fretz-Moon Tube Company was formed and continuously buttwelded pipe began to be made on a production basis. Year by year certain items of equipment were increased in size and capacity to meet the demands of a growing and more exacting market.

Although several mills were constructed outside of the United States during the next four years, it was not until 1938 that a large 3 in. mill installation was made in this country. Republic Steel Corporation and Spang-Chalfant Company had previously acquired a heavy interest in the Fretz-Moon Tube Company and the first large mill put in operation in this country was installed by Spang-Chalfant Company at their Etna plant.

Between the spring of 1938 and the fall of 1940, ten such mills have been put in operation in the United States and Canada. Two were installed by Spang-Chalfant Company, which is now a division of National Supply Company; one by Page-Hersey Tubes, Ltd.; two by Republic Steel Corporation; two by Youngstown Sheet and Tube Company; two by Bethlehem Steel Company and one by Wheeling Steel Corporation. The mills in their approximate starting-up order are shown, with their estimated capacities, in the accompanying table. The last mill to be started was the 4 in. Republic Steel Corporation's mill installed at Youngstown, Ohio.

It is perfectly obvious that during the two and one-half years that elapsed between the starting-up of the first Spang-Chalfant mill and the installation of the last Republic mill, certain changes in equipment were sure to be found desirable. These should be classed, generally, as improvements based on experience gained by all of those associated with the process. Some of these improvements have met with considerable success.

PRINCIPLE OF OPERATION

The basic layout for the continuous buttweld process is shown in view A of Figure 1. Briefly, the process is this: A coil of flat skelp is placed onto an uncoiling device at the beginning of the mill and the end of the skelp fed into a roller leveler. From this point the skelp is pushed into the flash welder, where the beginning of one coil is electrically welded to the end of the preceding coil. Unless the coils have been cut on the hot mill a cold shear is used to square the ends.

The welder incorporates trimmer blades, which trim the flash from the weld. The skelp then passes along through the pinch rolls. The purpose of this pinch roll unit is simply to pull the trailing end of the skelp after it leaves the leveler and position it in the jaws of the flash welder.

After the end weld is made and the skelp is trimmed, it is pushed out by means of the roller leveler onto the loop table. The roller leveler pays out skelp onto the loop table at a speed in excess of its travel into the furnace, thus forming a reserve to take care of the flash welding cycle.

While a weld is being made the loop decreases in size and it is up to the welding operator to complete his job before the loop is entirely drawn into the furnace.

From this loop table the skelp is dragged by means of the forming and welding mill, at the hot end of the

heating furnace, directly into the charging end of the furnace. The furnace itself could be likened to an elongated blow-torch. The one shown in Figure 1 has a 40 ft. preheat chamber without burners, and a 110 ft. heating chamber with burners along both sides, spaced on 9 in. centers.

The skelp rides through the furnace on water-cooled skid pipes and these prevent the steel from touching the furnace bottom, where it might pick up slag. All of the burners in the furnace make use of preheated air and they fire through the walls in such a manner that the flame impinges directly on the edges of the strip. With skelp for ½ in. pipe traveling through the furnace at 400 ft. per minute, this means that the strip must be heated from cold to welding temperature in 22½ seconds.

Immediately upon leaving the discharge end of the furnace, the hot skelp enters the first pair of rolls in the rolls. The last four pairs serve to reduce and size the pipe and to furnish traction for pulling the skelp through the furnace and forming rolls.

A flying saw placed just beyond the forming and welding mill cuts the pipe into standard warehouse lengths of 20 ft. or in lengths up to 70 ft., assuming the conveyor and cooling rack equipment are designed to handle these greater lengths.

These cut pieces of pipe are then carried away by means of a conveyor and dumped onto the first cooling rack. The principal purpose of this first cooling rack is to lower the temperature of the pipe to a point where it may be safely descaled and further sized. If it were descaled at too high a temperature, it would, of course, pick up added scale during the later operations.

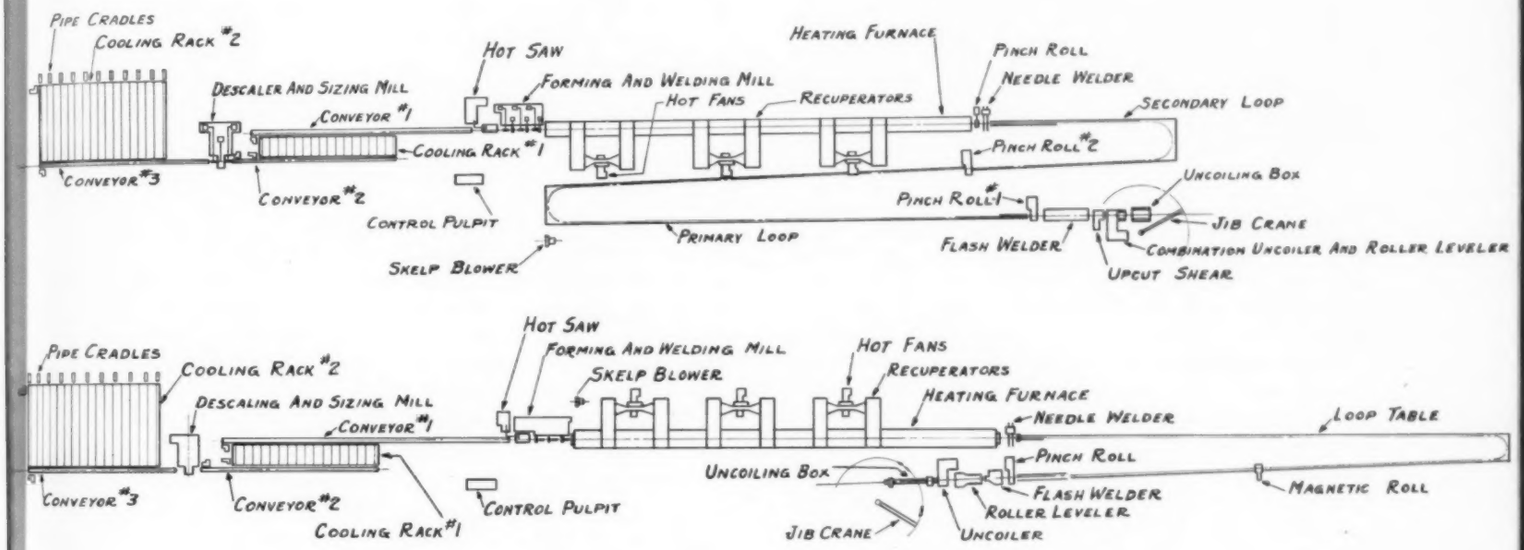


FIGURE 1—Basic layout for continuous buttweld process is shown in view A, bottom. View B, top, shows developments in later installations.

forming and welding mill. These rolls are actually less than two feet from the end of the furnace.

Between these rolls and the end of the furnace, however, there are three air nozzles which direct blasts of air on the edges of the skelp. This air not only cleans most of the scale from the skelp but it also serves to raise the temperature of the edges 100 to 200 degrees F. The body of the skelp is actually about 2400 degrees F. at this point, with the edges several hundred degrees hotter.

The first pair of rolls in the forming and welding mill form the skelp downward, with the edges still apart. The second pair form the complete circle and bring the edges of the skelp together. The welding of the edges by their own heat takes place here. The mill actually has three pairs of horizontal rolls and three pairs of vertical

Conveyor No. 2 carries the pipe from the first cooling rack and feeds it directly into the descaling, or sizing, mill. This mill includes three pairs of rolls, and the first pair squeeze the pipe slightly out of round to crack off the internal as well as the external scale. There is, of course, very little internal scale to be removed. However, what there is, is taken care of very satisfactorily by this unit. The second and third pairs of rolls bring the pipe back to its normal shape and do whatever sizing operation is desired.

The pipe is then taken directly to a second, and much larger cooling rack where its temperature is lowered so that it may be dumped into cradles or "bucks." Finally, it is carried to the finishing department where it is straightened; galvanized, if required; tested; threaded; and made ready for shipment.

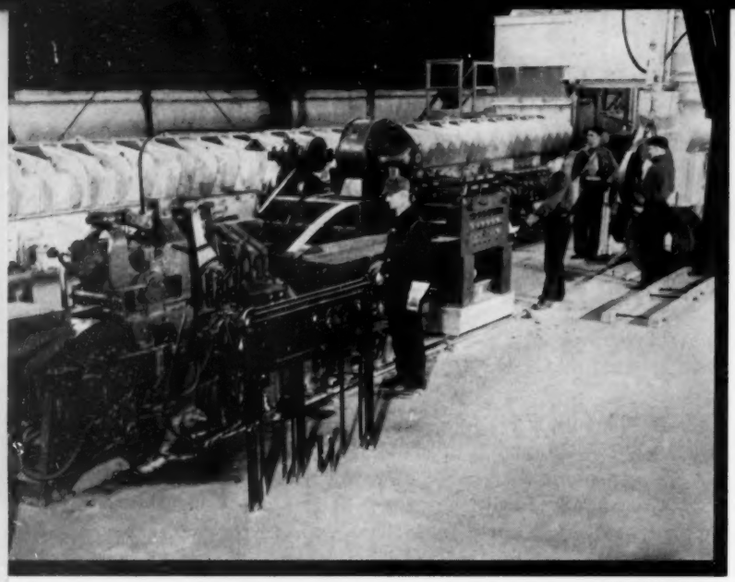


FIGURE 2—Skelp is fed through a roller leveler and into an electric butt-welder, where successive strips are joined together.

DEVELOPMENTS AND IMPROVEMENTS

The progress that has been made in the development of the continuous buttweld machinery is illustrated in view B of Figure 1. This shows the greater portion of the improvements that have been made on the various mills installed throughout the country.

On most of the initial installations, simple reel posts were used for supporting the skelp while it was being uncoiled. A jib crane is used for loading the coils from the adjacent racks onto the reel posts and wooden clamps hold the coil in shape. On later mills these reel posts were replaced with what we call uncoiling boxes, with an uncoiling trough. These boxes were only semi-automatic and it was still necessary for the operator to feed the skelp by hand into the roller leveler.

On the larger mills capable of making pipe up to 4 in. diameter, full automatic uncoiling machines have been found necessary. These machines operate in conjunction with the roller leveler.

With the reel posts or uncoiling troughs it is necessary to manually straighten the end of the coil so that it will enter the roller leveler. Inasmuch as it would be practically impossible to do this on the larger skelp without a machine, this automatic uncoiler is just about an absolute necessity.

All of the roller levelers for the mills making pipe up to 3 in. diameter have been of the 9-roll type. The first units had individual roll adjustment throughout, whereas the later ones, which were made somewhat heavier due principally to anticipated greater production, were equipped with larger diameter rolls, V-belt drives, and group adjustment for the rolls.

All of the 4 in. mills, however, used a roller leveler built in combination with the automatic uncoiling machine, which, as we have said before, eliminates almost all of the manual handling of the skelp between the uncoiling equipment and the roller leveler.

The flash welder on the last mill installed was made almost identical to the one designed for the first mill. This is a standard piece of equipment and the principal alterations included direct current motors in place of alternating current motors in some plants, plus a much heavier machine for the 4 in. mills than for the 3 in. mills.

One interesting feature, however, was the discovery that part of the trimming equipment could be eliminated by making the roller leveler do a little extra work. In most cases, there is an air-operated clamp provided on the welder to pull the skelp through the shear blades for the trimming operation. A short loop, therefore, as shown in Figure 2, was required between the roller leveler and welder.

If, however, the shear blades are held on the skelp and the skelp is pulled backward by means of the roller leveler, the same trimming action can be obtained and the loop between the leveler and welder eliminated. This loop has a tendency to become a permanent kink in the skelp and sometimes causes it to buckle and jam on the push-out from the roller leveler. Its elimination, therefore, is advantageous.

As explained before, the purpose of the pinch rolls is to position the skelp in the flash welder. Original units were built with single-roll drive, although some were later changed to a dual-roll drive.

Referring again to view B of Figure 1, it should be noted that a double loop has been used in place of the single loop described originally. This double loop arrangement calls for two pinch rolls, a primary pinch roll and a secondary pinch roll. The secondary pinch roll must be synchronized with the secondary loop so that a constant loop is maintained at all times. This permits a constant tension on the skelp through the furnace, regardless of the length of the primary loop.

The purpose of the primary loop is exactly the same as if a single loop were being used. The one outstanding advantage of this double loop arrangement is that it requires less length of building than the single loop. It also provides additional loop storage.

FIGURE 3—Approximately one-fourth of the furnace length, on the entry end, is devoted to a preheat chamber.

Although in most cases both primary and secondary pinch rolls were made identical, except, of course, with different controls, on one installation the secondary pinch rolls were made of the vertical type with the rolls at loop table level and the mechanism below. This has proven as fully satisfactory as the horizontal type, and is desirable where the secondary loop must be very short.

The first part of the heating furnace, shown in Figure 3, consists of a preheat chamber approximately one-fourth of the length of the entire furnace. This chamber is heated by spent flue gases from the heating chamber and the recuperator off-takes are so spaced as to allow the proper amount of gases to pass out through this preheat chamber.

On the original 3 in. mills, the furnaces were equipped with nearly 300 small burners firing through both sides of the furnace. The distance between the walls at skelp level is approximately 24 in., and the burners are designed to maintain a short flame in order that the hottest point will be at the edge of the skelp.

In order to assist in conveying the skelp through the furnace, it was originally thought necessary, due to experience abroad, to have driven rollers in the preheat chamber. These rollers were to be run at a speed slightly faster than the skelp travel and in each case a variable speed drive was provided to compensate for the different sizes of skelp.

With the introduction of the secondary loop, which is considerably shorter than the original single loop, it was believed that the driven rollers in the preheat chamber could be eliminated. One installation was made on this basis and the results were so convincing that on all of the most recently installed mills these driven rollers have been replaced with stationary water-cooled skid pipes, just as in the heating chamber.

For a rather complete description of the furnace itself we refer you to an article published in the IRON AND STEEL ENGINEER August, 1938. There are certain interesting features, however, that have been developed on the ten mills installed here in the last two and one-half years that we would like to discuss.

Three of the furnaces were designed to operate on natural gas, six to operate on coke oven gas and one on bunker C oil. The natural gas burner equipment was, of course, the easiest to put in operation. For the coke oven gas units, it was necessary to thoroughly clean the gas so that it would not clog up the very small burners.

The installation to be fired with bunker C oil presented a real problem and it was necessary to select the best type of atomizing equipment that could be found. The results of rather extensive tests indicated that the job could be done best with small mixer units, using steam for atomization and preheated air for combustion.

The mixer units chosen were designed to operate eleven burners. Superheated steam and oil were brought to the mixers in controlled quantities and the mixture of atomized oil and steam was forced out the eleven outlets under pressure.

On the first large furnaces installed in this country, metallic recuperators were chosen to preheat combustion air to approximately 1000 degrees F. The original recuperators were imported from abroad and on a still later furnace which made use of metallic recuperators,

FIGURE 4—View showing panel board carrying furnace controls. A recuperator unit is shown in the background.

it was found necessary to manufacture the units in this country.

After considerable study on the matter of recuperation on other heating furnaces, it was decided to try carborundum tubular recuperators in place of the metallic units. If this were done more recuperators could be used per furnace without excessive cost.

It was also believed that if the number of recuperator off-takes were increased, a more rapid transfer of heat could be obtained from the burners to the skelp. Investigations indicated that the gases were not getting away from the furnace fast enough, which, of course, had a very detrimental effect on the furnace brickwork.

On the first heating furnace, therefore, that made use of carborundum recuperators, six off-takes were provided and each off-take was equipped with a recuperator. This method proved so satisfactory that it was carried out on all of the remaining furnaces, except those that used metallic recuperators.

On all of the furnaces except one, the gases rise out of the furnace chamber into vertical off-takes, then pass through horizontal cross-overs and are pulled down into the recuperators. The recuperators, along with their framework, rest on the floor, and extend up to the horizontal cross-overs. After passing through the recuperators, the gases go down into a longitudinal flue running alongside of, or beneath, the furnace proper. At a convenient point, this flue has a connection to the main stack flue.

The one installation which is different from all the rest is located in a district where floods are prevalent. For this reason it was decided to put the recuperators

in the space ordinarily taken up by the cross-overs and to build the tie flue as a header above the furnace supported on building columns adjacent to the furnace.

The main stack flue connects to this tie flue near the center, just as in the other installations. It enters the stack at a point level with the tie flue above the furnace.

Although this is one of the most recent installations, the indications are that nothing whatsoever has been lost from the standpoint of economy or production due to this unusual design. As a matter of fact, actual fuel economy tests seem to prove that by letting the gases go straight out through the recuperators and stack there is something to be gained over the old method of forcing them down into a tie flue beneath the furnace.

On all of the heating units installed, automatic combustion control is provided. The purpose of this control is to maintain a constant and uniform atmosphere within the furnace chamber. An oxidizing atmosphere is generally conceded to be the most suitable. However, some units have been tried out, and are still running on a slightly reducing atmosphere. Regardless of which one is chosen, it is absolutely necessary to maintain it for all rates of firing.

A view of one furnace control board is shown in Figure 4. This particular installation made use of metallic recuperators and, therefore, required special control equipment for dilution air to protect the recuperators against possible overheating. The first three instruments shown at the left are the three combustion controls; the center section of the board is occupied by the controlling and recording instruments for dilution air to the recuperators. The right-hand end of the board contains the combustion air and flue gas pressure gauges, along with a skelp speed indicator and a recorder.

The temperature at the discharge end of the furnace is registered by means of a radiation type pyrometer. The temperature is approximately 2700 degrees F. within the furnace proper and about 2400 degrees in the skelp.

On all of the jobs that made use of carborundum tubular recuperators, the dilution air control was eliminated. In its place, however, it was necessary to install hot fan protection equipment so that the preheated air would not enter the hot fan at a point higher than the predetermined 1000 degrees F. On the metallic recuperator jobs, cold air is blown directly into the recuperators and they are forced to take the full pressure of the cold air system, which may be as high as 16 or 18 ounces.

On the carborundum recuperator jobs, air is sucked through the recuperators and, therefore, must be handled hot.

The forming and welding mill, shown in Figure 5, is the piece of equipment around which all of the other units must be built. Naturally, the original mills followed pretty closely one general line of design. They made use of one main drive motor, with partially open gear drives. The change in pipe speed from one end of the mill to the other was compensated for, as well as possible, by means of different diameter rolls.

Experience gained on these mills indicated that a heavier construction would be justified and the last group of 3 in. mills installed were, we should say, approximately 50 per cent heavier. They also included

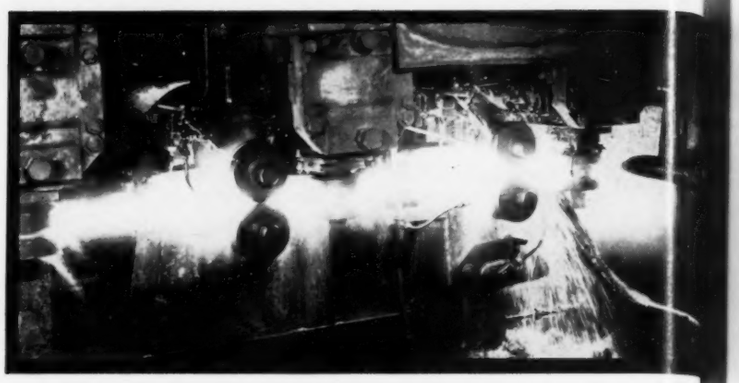


FIGURE 5—As the skelp leaves the furnace, it passes through air jets and on through the forming and welding rolls.

centralized lubricating system, lubricated universal joints, two gear boxes only, and all gearing enclosed, with a motor-driven oil circulating system.

A further revision constituted changing from two gear boxes to one gear box only, which drove both the vertical and horizontal rolls.

When the 4 in. mills were constructed, however, the design was changed completely. There are three of these 4 in. mills in operation in this country and all of them use a design incorporating a separate drive motor for each pair of rolls. This means six 25 hp. motors in place of the one 40 or 50 hp. used on the smaller mills. Each of the six motors is equipped with a separate

FIGURE 6—View showing operator's control board, which should be as close to the forming and welding mill as possible.

variable speed control and with an ammeter for indicating motor load. The difference in speed was compensated for, in the original mills, with one motor by means of varying diameter rolls. With the six drive motors, the variation in speed can be taken care of electrically. This follows with the principle of other continuous units, such as the new strip mills, and it has shown a marked reduction in roll wear.

The six ammeters indicating loads on the six motors are placed in front of the mill operator at the control pulpit. The proper load for each motor has been worked out by theory, and by practice, and the operator keeps these loads constant with the speed controllers he has in front of him.

The location of the mill operator's control pulpit, as shown in Figure 6, should be as close to this forming and welding mill as practical. About the best way the operator has of telling whether or not the skelp is welding properly is to look at the hot metal leaving the furnace and at the scale being blown from the edges, and determine if it is at the proper temperature. If the skelp is too hot, he speeds up the mill, thereby running more steel through the furnace. If it is not hot enough, he slows the skelp down.

There is, therefore, no need for any temperature control on the furnace proper. Once the mill speed has been brought up to a satisfactory rate to correspond with the heat input to the furnace, very few additional adjustments are necessary. After a threading operation, however, and while the furnace is being brought up to maximum temperature and the mill to maximum speed, the operator has a task that requires the utmost skill.

For many years the automatic hot saw, shown in Figure 7, has been a bottle-neck in the production of continuous buttweld pipe. Maintenance on such a unit is bound to be high, and many adjustments are necessary for cutting the several pipe sizes at the varying speeds.

The original hot saws received their motive power for the carriage from the forming and welding mill motor through an adjustable speed drive. A solenoid operated friction clutch, actuated by means of a flag switch located in the pipe trough, engaged at the proper moment and caused a crank to make a complete revolution. A suitable connecting rod linked this crank to the saw carriage. The saw carriage, therefore, would move out slowly at first in the direction of pipe travel; would reach a maximum speed; and would then slow down and return. At the proper point in its outward travel, the saw blade, with its direct connected motor, would dip forward and cut the pipe.

Naturally, with the carriage moving out on a crank motion, there was no point at which the carriage was traveling at exactly the same speed as the pipe, except for more than a fraction of a second. This caused a certain amount of wear on saw blades, and gave a nominal cutting tolerance.

Based on experience gained from the use of the original saw, a new one was developed in which the cutting tolerance averages plus or minus $\frac{1}{8}$ in. In this design, just as in the other, the driving power for the carriage is received from the forming and welding mill motor. The flag switch operates a clutch, which is of a roller clamping design, and this, in turn, rotates a cam one complete revolution. The saw carriage, therefore, is linked to a cam action instead of a crank motion, and the cam is designed so that during the outward stroke of the saw carriage there is a definite period of time in which the carriage moves at exactly the same speed as the pipe is traveling.

During this constant travel period, the saw blade is made to dip into the pipe and cut. Instead of tipping forward both the saw blade and motor, as in the original design, the motor is held stationary on the carriage and the saw blade pivoted around the motor shaft. Power is transmitted from the motor shaft to the saw arbor by means of a V-belt drive.

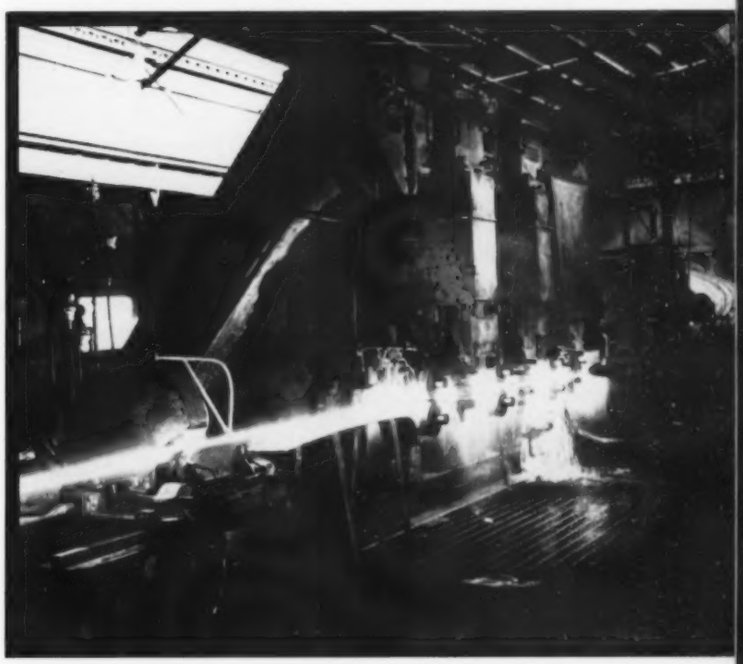


FIGURE 7—Closely following the mill is the automatic hot saw, several designs of which are available.

Naturally, when cutting pipe traveling at either a slow rate or a fast rate, the amount of time required for all of the mechanical operations in the saw to take place, such as the action of the clutch, is the same. If the pipe is moving slowly, it will not advance as far along the pipe trough between the time it strikes the flag switch and the moment it is cut off, as it would if it were moving rapidly. To get absolutely uniform lengths at all speeds, therefore, it would be advantageous to shift the flag switch to a slightly different position for each different pipe speed.

The design for a mechanism which will automatically move the flag switch to compensate for changes in mill motor speeds has been developed. Such a device as this would give just about the ultimate in cutting tolerance.

A third design, known as the Stevens-Wilson design, operates on a somewhat different principle. A separate motor moves the saw carriage and this motor is controlled by the same electrical equipment that varies the

speed of the forming and welding mill motors. The carriage moves back and forth continuously at varying speeds, and dependent on the length of pipe to be cut, the blade dips forward on every stroke, every second stroke, every third, fourth, fifth, or sixth stroke and cuts a length of pipe.

The distance of the saw carriage travel may be varied to get an infinite number of required lengths. All adjustments are made by means of electrical equipment operated from a central control board. Regardless of whether the pipe is traveling fast or slowly, the cutting tolerance is always maintained at a small fraction of an inch.

The original sizing mill was substantially a converted forming welding mill, using single groove rolls. Some mills were built following very closely this design, with the exception that all gearing was enclosed and running in oil.

Experience, however, indicated that a heavier construction (see Figure 8) would be of advantage here also, and it was thought possible to make double groove rolls for the smaller size pipe. On one mill a special quick adjustment feature was added in order to shift from one pass line of the double groove rolls to the other.

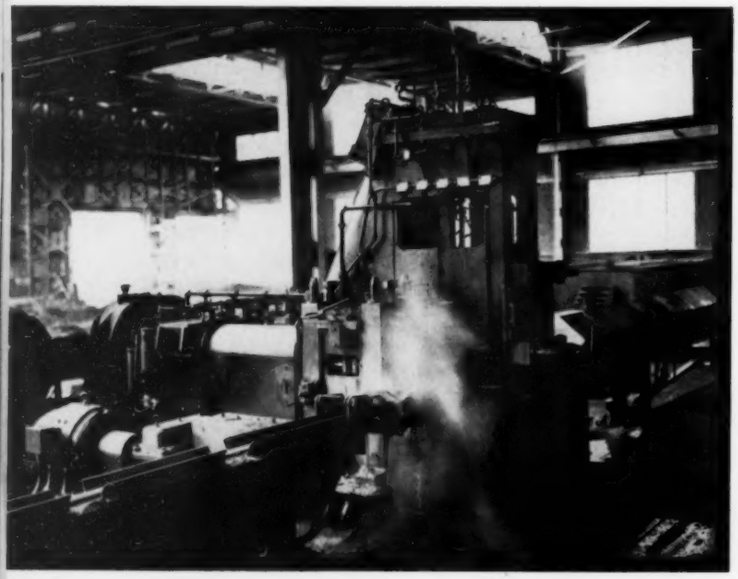
As stated before, three pairs of rolls are required for this mill. The first cracks the scale from the pipe by deformation; the second and third pairs perform a sizing operation.

On all of the 4 in. mills, the same individual drive feature was used as on the large forming and welding mills. Each drive motor was equipped with an ammeter for determining the proper load to be applied, and all rolls were made the same diameter.

Double groove rolls were not deemed practical because of the very large size pipe being handled.

On one of the 4 in. mills a regular X-type sinking mill was installed, with three stands, each having individual drive. Single pass rolls were used here also.

FIGURE 8—In the later installations, construction of the sizing mill has been heavier, using double groove rolls.



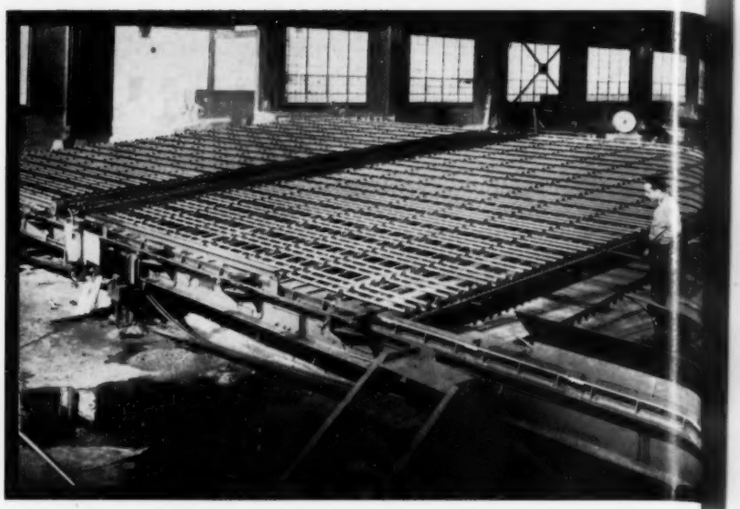


FIGURE 9—View showing standard chain type cooling rack. Chain conveyors were also used in this installation.

Several types of conveyors are now in operation on this continuous buttweld equipment. Roller type conveyors, with plain bearings were at first believed to be quite satisfactory. Later designs used the same type conveyor, but with anti-friction bearings.

In one particular plant (see Figure 9) where chain type conveyors are set up as standard equipment, these were used throughout the continuous buttweld mill.

On installations that followed, chain conveyors were used in several cases for conveyor No. 2, which carried the pipe from cooling rack No. 1 to the sizing mill.

One outstanding advantage of the chain conveyor here over the roller type is that it does not cause scallops in the pipe, such as are sometimes found when the hot pipe is dropped from the cooling rack onto a roller type conveyor. Also, in mills where the equipment is set up so that two lengths of 20 ft. pipe can be handled by the cooling rack at one time should the piece of pipe farthest away from the sizing mill drop onto the conveyor ahead of the other piece, it would be imperative to get it out of the way and into the mill as quickly as possible. The chain conveyor can accelerate the pipe much faster than the roller type and, therefore, is better for this purpose.

For conveyor No. 1, which carries the pipe from the hot saw to cooling rack No. 1, there seems to be a preference for the roller type because kick-offs are required here. This same reasoning holds true for conveyor No. 3, which carries the pipe from the sizing mill and kicks it off onto cooling rack No. 2.

The cooling racks are all made similar in design and are standard chain type racks. The majority of the units operate from direct current, variable speed motors. In some cases a two-speed gear box was added on cooling rack No. 1, and used in conjunction with the 4 to 1 variable speed motor.

To thread the heating furnace (see Figure 1) it was originally thought that a piece of pipe, known as a needle, exactly the same size as that to be welded, would have to be used. The procedure was to push this needle through the furnace and into the forming and

welding mill. The skelp would then be welded to the end of the needle. The forming and welding mill, aided by a crane or cable haul, would pull the needle and hence the heated skelp through the furnace.

This meant that a needle would have to be available for each size of pipe. For the larger sizes, it was an almost impossible job because of the enormous weight of the needle.

A further development was the discovery that a very small needle could be used and that this small needle could, of course, be put through the furnace and mill with less manual labor. A special tag end was welded between the needle and the entering skelp to guide the skelp correctly into the forming and welding mill. This is the procedure used on most of the installations and is far more satisfactory than the original method.

A rather unique method of threading developed by one plant eliminates entirely the use of a threading needle. It is based upon the same principle as is used in a winding type steel rule, in that the steel strip is curved to give it strength.

Just before the skelp enters the furnace it passes through a special set of rolls which curve the edges downward. This gives the strip sufficient strength so that it may be pushed all the way through the furnace by the above rolls. It is then fed directly into the forming and welding mill.

In order to cut down skelp breakage and in an attempt to maintain constant tension on the skelp being pulled through the furnace, several installations have been provided with magnetic rolls reeding the skelp into the heating furnace (see Figure 4). Magnetic rolls have also been used in No. 1 loop to facilitate carrying the lighter skelp out on the loop table.

Two other interesting features that have been added in certain mills are: A pinch roll located between the

TABLE I

CONTINUOUS BUTT WELD (FRETZ-MOON) PIPE MILLS

UNITED STATES

Company	Location	Construction started	Size pipe rolled, in.	Estimated annual capacity, tons
Fretz-Moon Tube Company, Inc.	Butler, Pennsylvania	1922	1/8 to 1	42,000
Fretz-Moon Tube Company, Inc.	Butler, Pennsylvania	1924	3/8 to 2 1/2	75,000
Spang-Chalfant Company	Etna, Pennsylvania	1938	3/8 to 3	85,000
Republic Steel Corporation	Youngstown, Ohio	1939	1/2 to 3	85,000
Youngstown Sheet and Tube Company	Youngstown, Ohio	1939	1/2 to 3	85,000
Bethlehem Steel Company	Sparrows Point, Maryland	1939	1/2 to 3	85,000
Youngstown Sheet and Tube Company	Indiana Harbor, Indiana	1939	1/2 to 3	85,000
Wheeling Steel Corporation	Benwood, West Virginia	1939	1/2 to 3	85,000
Bethlehem Steel Company	Sparrows Point, Maryland	1939	1 to 4	150,000
Spang-Chalfant Company	Etna, Pennsylvania	1939	1 to 4	150,000
Republic Steel Corporation	Youngstown, Ohio	1939	1 to 4	150,000
Total capacity, United States plants				1,077,000

FOREIGN

Stewarts and Lloyds	Corby, England	1933	1/8 to 1	42,000
Stewarts and Lloyds	Corby, England	1933	3/4 to 2	85,000
Stewarts and Lloyds	Corby, England	1933	3/4 to 2	85,000
Stewarts and Lloyds	Australia	1933	1/8 to 3	42,000
Vereinigte Stahlwerke	Mulheim, Germany	1932	3/8 to 3	85,000
Vereinigte Stahlwerke	Mulheim, Germany	1933	3/8 to 3	85,000
Vereinigte Stahlwerke	Mulheim, Germany	1933	1/8 to 1	42,000
Page-Hersey Tubes, Ltd.	Welland, Ontario, Canada	1939	1/8 to 3	85,000
Total capacity, foreign plants				551,000
Total world capacity				1,628,000

Estimated speed, ft. per min., depends on size pipe in all cases. Maximum on 3/8 in. to 3 in. mill is 400 ft. per min. Maximum on 1 in. to 4 in. mill is 300 ft. per min.

forming mill and the hot saw to take place of a cable haul in pulling the threading needle out of the furnace; and still another pinch roll at the cold end of the heating furnace to pull the skelp from the furnace in case of skelp breakage.

Continuously buttwelded pipe has now become an important factor in the pipe market. The majority of the larger plants in this country were put in operation within a very short period. Unfortunately, therefore, it has not been possible to profit by the experience gained in each installation consecutively and develop, as a result, the one super plant.

On the other hand, it should be remembered that there are ten mills in operation, distributed over six steel companies. Each company, along with the designers of the equipment, is developing day by day a better knowledge of the intricacies of operation. Many men are "on the job," which is sure to mean but one thing—a better pipe made by a better process.

J. H. LOUX

E. T. TREBILCOCK

DISCUSSION

PRESENTED BY

E. L. APPLEGATE, *Superintendent of Pipe Mills,* Youngstown Sheet and Tube Company, East Chicago, Indiana.

J. D. JONES, *Chief Engineer,* Youngstown Sheet and Tube Company, Youngstown, Ohio.

C. H. VERWOHLT, *Assistant Superintendent,* Tube Mill, Wheeling Steel Corporation, Benwood, West Virginia.

E. L. APPLEGATE: It is interesting to note that the first continuous butt weld pipe mill had a furnace 10 ft. long fired by one oil burner and cost $525.00 complete, and that its maximum pipe size was ⅛ in. No doubt, the eight hour turn production on such a mill was less than a ton.

Contrast this first mill with the latest continuous butt mill placed in operation, which has a furnace 156 ft. long, is fired by 334 burners, has a maximum pipe size of 5 in., and has produced close to 200 tons of 3 in. pipe and will probably produce 225 to 250 tons per eight hour turn on 4 and 5 in. pipe. The cost of such a mill would average from $450,000 to $700,000, depending on the completeness and elaborateness of the equipment. The continuous type mill gives improved welding control, less scale and cinder, and a more uniform size.

With ten of the later type continuous butt mills now in operation, improvements will continue to be made seeking to increase production, improve quality, reduce operation and fuel cost, and also reduce furnace maintenance and equipment repair costs.

It may be interesting to point out some of the difficulties various operations have encountered, which in most cases led to substantial improvements. To successfully operate a continuous butt mill it is necessary to have straight skelp with good edges, evenly coiled, and with skelp ends sheared square and straight vertically. Crooked or cambered skelp or short coils are a distinct handicap to the operation of a continuous butt mill. It is beneficial to have large coils, *i.e.*, the maximum feet of skelp in each coil, to cut down the number of end welds and conserve welding time. Such skelp is a great advantage in the leveler, end welder and stripper operations and permits the running out of a long primary loop without difficulty, such as buckling and twisting of the skelp on the coil bed.

The ease of handling coils of skelp up to 6.68 in. in width for 1½ in. pipe in a coil box, as compared to using reels, has justified this improved equipment.

Likewise, difficulty in uncoiling by hand skelp 8.347 in. in width and wider for 2 in. pipe and larger has made it necessary from a speed of operation and a labor saving standpoint to install mechanical uncoilers for mills making the range of sizes from 2 in. up. This is a definite improvement when it is considered that two end welder helpers can do with an uncoiler what five to six men struggled to do by hand with the consequent speeding up of operations.

The addition of some type of shear for squaring skelp ends is an advantage where poor or out of square shearing has been done on the skelp mill, or in cases where skelp for 4 in. and larger pipe has been rolled with flag ends unsheared. If for some reason a poor weld is made, the bad ends may be sheared off and a new weld made, all of which is an advantage to operation.

Considerable improvement can be made in the shearing of flash from the electric welded end welds now accomplished by a pair of plow type shears, one on top and one on the bottom of the skelp, and, no doubt, changes will be made to perfect the end weld and completely eliminate its appearance in the finished pipe.

The double loop for skelp is an improvement over the single loop, as the secondary loop places a definite tension on the skelp passing through the welding furnace, which neither live roll nor driven magnetic rolls could accomplish. Some mills use a smooth concrete floor for a loop bed, while others use cobble stones or granite blocks to secure a point contact between the skelp and the floor.

A long line of idle rolls down the first leg of the primary loop and at floor level appears to be the best means of facilitating a long reserve loop of skelp. The idle rolls are an improvement over two pairs of magnetic rolls set at loop bed elevation to accomplish the same purpose. Such rolls reduce friction between the loop floor and the skelp which enables the operator to push out a longer primary loop.

The use of the leveler to pull the welded skelp back in stripping the flash from the end welds is an improvement as it removes the kink and resultant buckle in the skelp which gives trouble in the primary loop where the forward stripping was accomplished by use of the air operated clamp. Removal of this kink in the skelp likewise makes possible a longer loop as a reserve ahead of the end welder.

The welding furnaces equipped with six carborundum recuperators, where the gases rise out of the furnace chamber into vertical uptakes, seem to be an improvement over the furnaces with three metallic recuperators since they facilitate a more rapid transfer of heat from the burners to the skelp and allow the hot gases to pass from the furnace more rapidly, thus saving rapid deterioration of brick work.

Considerable improvement can be made in furnace brick work. The most successful burner block appears to be made from mullite grain and formed by tamping when wet into a mold with an air ram. Silica brick has been used successfully for roof bungs and sidewalls. Super duty fire clay brick has been used for sidewalls, also chrome ore and chrome brick on furnace bottom and in cinder pockets has given good service.

The removal of cinder from the furnace has been a problem on most mills. Some concerns have placed water cooled slabs under the cinder holes to granulate the cinder so that it could be readily raked from the furnace through the cinder spouts. To date, most mills have difficulty in removing cinder from the continuous type furnace and there is opportunity for improvement in that line.

Forming and welding rolls with one enclosed gear box and a centralized lubricating system are a material improvement. On the larger mill, individual drives for each set of rolls permit distribution of the load and more accurate control of the forming and welding through separate speed controls. This also saves roll wear.

The newer type saw carriage linked to a cam action instead of a crank motion has improved the accuracy of cutting pipe to length since in driving the outward stroke of the saw carriage there is a definite period when the saw and the pipe move forward at the same speed at which time a square saw cut is made. However, frequent adjustments in the flag actuating the saw cuts must be made at time when the mill is speeding up or slowing down. It is possible to develop a control which will cut accurate lengths at any speed and this will, no doubt, be accomplished in the near future.

The Stevens-Wilson design of saw with the continually moving carriage is very good for pipe sizes 2 in. and up, but could not be used without difficulty on ½ and ¾ in. where the pipe travel speed is much faster since the fast continual motion would pound the equipment too severely.

The double grooved feature for descaling and sizing mill rolls is an improvement for small pipe sizes up to 2 in. Where grooves can be changed by moving the rolls over rapidly without a stop on the mill, longer runs on a size may be accomplished.

Individual drives for descaling and sizing rolls for pipe sizes 3 in. and up is an improvement. Three sets of rolls of the sinking mill type are being used in one mill with spare housing for setting up for next size to be made on the mill. Very uniform size may be obtained from such an installation and roll change time saved.

Chain type conveyors are more positive and accelerate pipe speed when used to convey pipe from No. 1 rack to the sizing mill. Chains cause less dinges or scallops than live rolls, but are more expensive to maintain. Roller conveyors are a distinct advantage on No. 1 and No. 3 conveyors where hot pipes have to be kicked off onto cooling racks.

Improvement can be made in threading the furnace by use of pinch rolls replacing cable hook. Skelp formed to curve the edges downward, like the roll type steel rule, can be charged through the furnace on large sizes, but with rough furnace bottom would cause difficulty on small sizes of skelp for ½, ¾ and 1 in. pipe.

Many of the developments on continuous butt mills have come along so rapidly that only time can tell how practical some of them are. It is possible to add so much detailed equipment and control apparatus to such a mill that it becomes too complicated for successful operation. The chief fault in the design of the modern continuous type mill is that it has been too light in construction to stand the pounding of operation. This is something that can be readily overcome, and the later type mills have been of heavier construction.

J. D. JONES: Just as a matter of interest in discussing the relative tonnages of the newer type of mill

with the older type, I think we still have to find out a lot about how far we can go. In other words, on 2 in. pipe, for instance, just the other day a mill at Youngstown ran over 500 tons in 24 hr., and 2 in. is a nice section to roll. I think we have to get rid of a few preconceived notions that we have had about these mills. Of course, it is quite true that we have had less than a year's time in which to think about these possibilities and work them out.

C. H. VERWOHLT: I don't want to take up any time going over points which have already been satisfactorily discussed, but since we seem to be regarded as unconventional as regards some of our installations, perhaps some of the unconventional points will bear describing.

Our coil box uncoiler is just a little bit different from the rest. Redesigned from the standard unit that was supplied to us, it is now working very well. Our loop was laid out a little bit differently from the rest of the mills in that we put our uncoiler and welding unit about 6 to 8 ft. from the center line of the furnace, feeding our skelp down directly alongside the furnace and allowing the loop to form out away from the furnace instead of toward the furnace as was shown in the illustration in the paper.

This method allows us to accumulate more stock in this primary loop than can be accumulated on the other type in that the loops can always be shoved out away from the furnace. This is a very great advantage sometimes, particularly if we are changing from a standard gauge to a heavier gauge and we want a little extra time at the welder. We have time enough by means of this extra loop on the floor to change our welder equipment for the heavier gauge. This is of some advantage because we do not have to stop the furnace.

The pinch roll in our case is a vertical pinch roll, and it is working very successfully. It gives us very good control on the secondary loop. The electric control in the secondary loop is as discussed in the paper. However, we just woke up to the fact a few days ago that this control was giving us too violent fluctuation in the secondary loop, and very often the loop would run out from under the control fingers, especially when we were working on one-half or three-quarter inch pipe at the higher speeds. This was caused by a holding coil on these controls. All we did was to cut out the holding coil and now the loop rides against either the finger that speeds up the loop or the one that retards it, and part of the time it rides free of both, which is a much better arrangement.

Our threading scheme again is something different than the conventional method. This scheme was described in the original paper but I just want to add a word to it and say that it really is working on all sizes from ½ in. to 3 in. pipe. We are having very, very little trouble in putting the skelp through the furnace with our forming rolls. Once in a while on the ½ in. and ¾ in. we will get a tangle in the furnace when we shove it in, but that is very seldom. The method is quick. We hook on to the skelp, after it is pushed through the furnace, with a pair of old type pipe tongs and start them through the mill. We have had skelp going through the mill in four to five minutes from the time we started from the back end.

The furnace brick work has been touched on by Mr. Applegate. There is certainly something to be desired in the form of brick work. The furnace was furnished with one type of brick that did not prove any too good. There have been several other types tried out, particularly burner blocks. Some of us have paid as much as $11 a unit for burner blocks, and perhaps that is too much. I think something will be developed that will prove more economical per ton of product made.

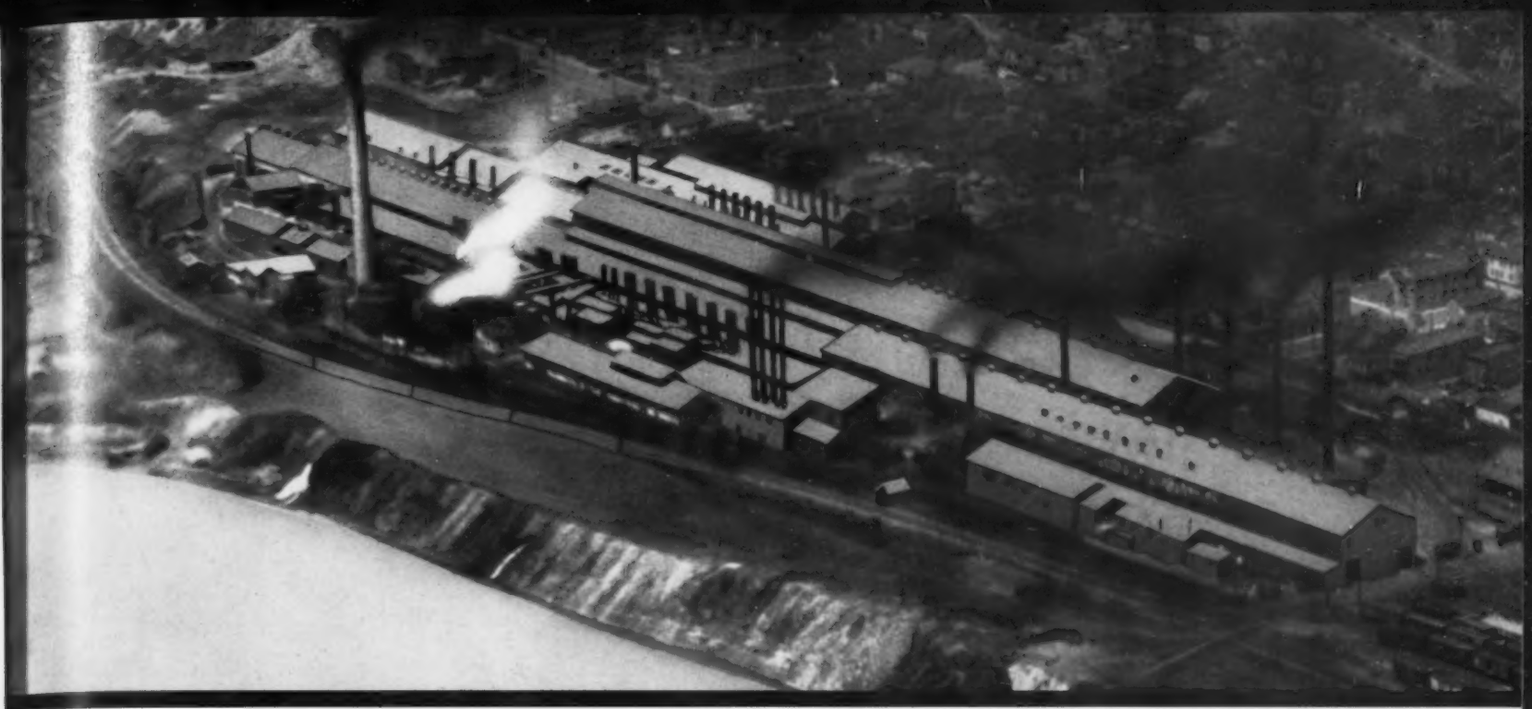
On the mill itself we thought we were going to profit by some of the other people's experience by getting a mill that was tight enough to keep the scale and dirt out, and that could be easily adjusted, but we find that there is still much to be desired in that respect. We are making a practice now of cleaning one mill every Sunday. Our mills are working on a twenty turn per week basis, and we use the twenty-first turn to take one unit of the welding mill apart to clean it up each Sunday so that we can keep the adjustments free and in order.

One other thing in connection with the furnace. I believe Mr. Applegate mentioned the water-cooled bottoms for the slag. I want to say that these water-cooled bottoms are working very successfully and we have very, very little trouble in removing the slag from the furnace. The slag is always cooled down enough so that it breaks up easily.

The rest of our equipment is of a conventional type, as described in the paper. On the descaler we have the hydraulic shifting arrangement for moving from one groove to another on the rolls, and we find that this works very well, although we cannot move over in the space between a couple of pipes. It requires some little time to readjust the rolls when we move from one worn groove into a new groove. However, the time is very short compared to what it would be if we had to move the mill over by hand.

Our straightener is something different, I believe, than any to be found on any other mill, in that we have a hot pipe straightener back of the descaler. This is a screw-type straightener that was developed by one of our men, and that was first used on one of the old butt weld mills. We believe that the one used on this continuous mill is an improvement, and it is working very well in that it gives us something like 90 per cent straight pipe without cold working.

There was something mentioned about the location of the control equipment for the welding mill. I think this is a very important item. In some of the mills, it seems to me, the control equipment was put in too far away for the operator to be able to see the skelp as it comes out of the furnace and to know what the temperature is. We have located this equipment directly in front of the welding mill and find that it works very successfully.



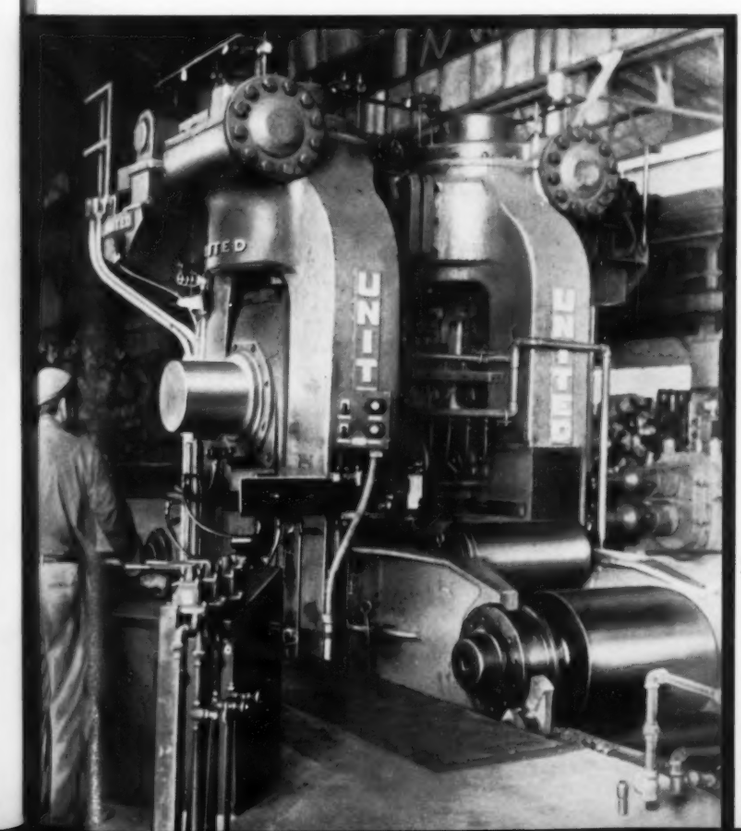
FOLLANSBEE STEEL CORP.

Expands Cold Reduction Facilities....

By T. J. ESS

with personnel photographs by J. R. SCOTT

Two duplicate reversing mills, 12 in. and 37 in. x 34 in., provide facilities for tin plate production by modern methods.



▲ THE Follansbee Steel Corporation is the continuation of a business established early in the 19th century. The Follansbee name has been identified with the business since 1894, and the third generation is now active in the organization. With the development of the tin plate industry in the United States, following the passage of the McKinley tariff act, a predecessor company operated a dipping plant in Pittsburgh, for which the supply of black plate was purchased. With the growth of this business, it became desirable to control the required supply of black plate, and in 1902, 250 acres of farm land were purchased on the Ohio River, in Brooke County, West Virginia, by Follansbee Brothers Company. On this property is located the town of Follansbee, incorporated in 1906, and a sheet and tin plate plant. Later developments led to the desirability of further integration of production facilities, resulting in the construction of an open hearth and rolling mill

W. T. BROWNSCOMBE

PRESIDENT

C. H. MANION

VICE PRESIDENT IN CHARGE OF OPERATIONS

plant, together with a sheet mill, at Toronto, Ohio. This plant started operations in 1921.

Keeping abreast of the industry, the company, with the advent of the cold reduction methods of production, installed one of the first cold reduction tin plate mills in the industry. An extension of this policy is the recent addition, at the Follansbee, W. Va., plant, of two new reversing cold mills and a temper mill, with the necessary finishing and auxiliary equipment. This new installation, in conjunction with the previously existing equipment, offers a high degree of flexibility in flat rolled operations, a factor which readily lends itself to the production of a wide range of specialties. Follansbee is said to be one of only two companies in the country which is in a position to furnish all grades of charcoal tin plate, coke tin plate and terne plate, and also specializes in electrical sheets for all standard or special requirements. Much of the product is required to meet special, exacting specifications, of analyses, treatment, and finish developed through long experience.

Annual capacities for various products are now as follows:

The addition of the new cold mill equipment necessitated the extension of existing mill buildings.

COLD REDUCTION MILLS

The two new four-high reversing cold mills are duplicates, but of opposite hand. They are 12 in. and 37 in.x 34 in. units, designed to roll up to 31 in. wide down to tin plate gauges averaging .01 in., with a minimum thickness of .006 in. Coils weighing up to 450 lb. per in. of face width may be handled, with an inside diameter of 30 in., and a maximum outside diameter of 54 in. Each mill has a nominal capacity of about 3200 net tons per month. Rolling speeds of 942–1570 ft. per min. are attained.

The mill housing is of cast steel closed top design Housing posts have a cross-sectional area of 500 sq. in. each, and the housing windows are 42 in. x 12 ft. 6 in. Both of these mills are arranged so that they can be widened 6 in. if desired in the future. Forged steel work rolls (12½ in. maximum diameter, 11½ in. minimum) run in roller bearings 6½ in. x 9⅝ in. x 7⅜ in. Back-up rolls are of special cast steel, and run in 34 in. oil film bearings. These bearings are mounted in cast steel

chocks held by latch type clamps. The hydraulic roll balance operates through cylinders located in the bottom work roll chocks and bottom back-up roll chocks, pressure being supplied for both mills from a self-contained hydraulic system complete with pump, sump tank, accumulator, valves and piping.

Each mill is direct driven, through a gear type flexible coupling and a totally enclosed stand of forged steel, roller-bearing, pinions. Forged steel mill spindles are of universal type, spring balanced. The drive motor is a 1500 hp. 300–500 rpm., 600 volt d-c. totally enclosed unit, designed for speed regulation of 2 per cent at maximum rated speed and 4 per cent at minimum speed, from friction load to 100 per cent load. From friction load to 200 per cent load, these percentages double.

Rolls are adjusted through a double worm reduction screwdown drive of 1029:1 ratio, driven by two 25 hp., 375 rpm. d-c. motors and a magnetic clutch. The screws are of forged steel, 14 in. in diameter, .40 in. pitch, and operate in screw boxes of extra strength bronze.

Coils, tightly wound, are placed as desired into a cone type unwinding reel at the entry side of the mill, and the leading end of the strip is fed into the mill by a pair of pinch rolls. Hydraulic brakes are applied to the uncoiler to provide back tension on the first pass.

The reel drums are solid cast steel, 30 in. in diameter and 34 in. long, with machined slots into which the end of the strip is inserted, so arranged as to give a reverse bend to the strip. Each reel is driven through a gear set of 4.8:1 ratio by a 750 hp., 400/800 rpm. 600 volt d-c. motor. On each reel motor shaft is mounted one 200 watt, 250/250 volt special generator which runs at 1725 rpm. at top speed of the mill, and actuates the field rheostats in controlling reel tension.

Strip passes over 12 in. deflector rolls on each side of the mill. Cast steel entry and delivery guides with brass strip liners are provided. Entry side guides are adjustable through a hand-wheel and right-and-left hand screw.

When a coil has been rolled to the desired gauge, the loaded drum is rolled clear of the mill on rails provided for the purpose, and the strip is removed by recoiling on a collapsible head reel. Each drum has a square hole in the outer end of the shaft into which a square bar is inserted while recoiling. The bar is connected through a clutch to adjustable hydraulic brakes, so that tension may be applied to the strip while recoiling.

M. A. FOLLANSBEE

GENERAL SALES MANAGER

The main drive and reel drives of each mill receive power from a motor-generator set consisting of one 1250 kw., 600 volt generator, one 600 kw., 600 volt generator, one 300 kw., 280 volt reel booster, and one 50 kw., 250 volt exciter, all driven at 720 rpm. by a 2250 hp., 2300 volt synchronous motor. Each mill is also provided with an auxiliary set composed of two 3 kw., 125 volt regulating exciters driven by a 10 hp., 220 volt, 1160 rpm. squirrel cage motor. These exciters energize the auxiliary fields of the entry reel generator and the delivery reel booster generator.

The entire mill unit operates under variable voltage control, with speed controlled by motor-operated rheostats acting on the generator and motor fields. Rheostats, with adjustable resistance, are in the shunt fields of the operating motors, so that speed of operation may be varied to give desired rates of acceleration of mill and reel motors. Control equipment for the reel motors is arranged to maintain constant tension, backward and forward. Reel motors are so constructed that the trailing reel acts as a generator, delivering power to the forward reel. The booster generator acts to maintain

E. E. BOWEN

PLANT MANAGER

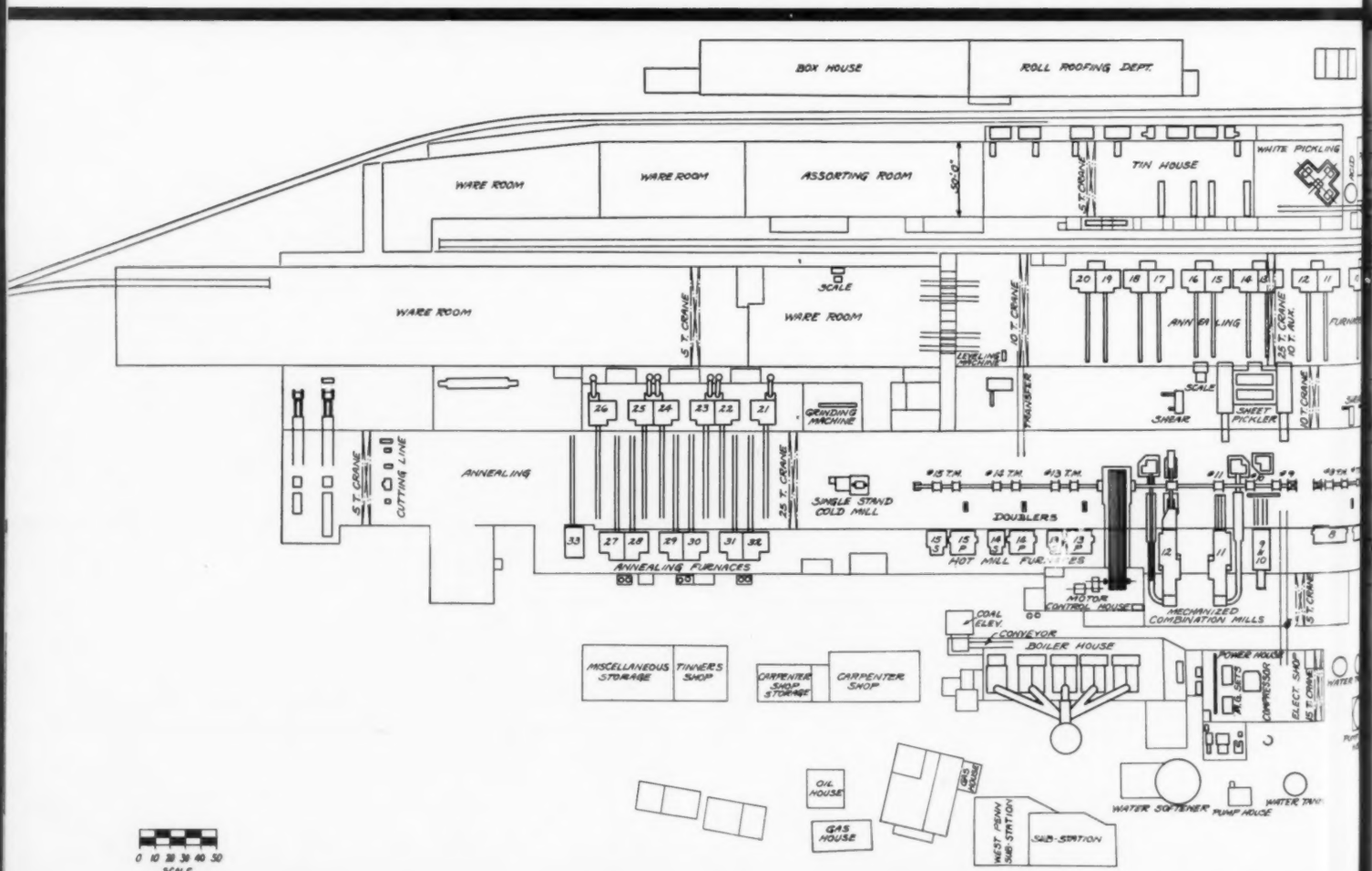
J. S. MURRAY
CHIEF ELECTRICAL ENGINEER

H. J. EVANS
PLANT SUPERINTENDENT, TORONTO PLANT

tension on the strip at stand still and at very low speeds. At higher speeds, the booster supplies the differential in voltage and power between the trailing reel motor and the forward reel motor, and also supplies the losses in the circuit at all speeds and at stand still. Reel motors and booster generator are excited from individual pilot exciters.

Control switching is so arranged as to connect either of the two reel motors to the reel generator for inching. The pilot exciters have field reversing contactors for reversing the voltage, allowing independent inching. Tension regulators have special compensatory windings so connected that, when the mill is accelerated, torque on the forward reel motor is increased in proportion to the rate of acceleration, and torque on the trailing reel motor is decreased in the same proportion. While decelerating, torque on the forward reel motor is reduced, and torque on the trailing reel motor increased, by amounts proportional to the rate of deceleration.

During acceleration or deceleration, maintenance of



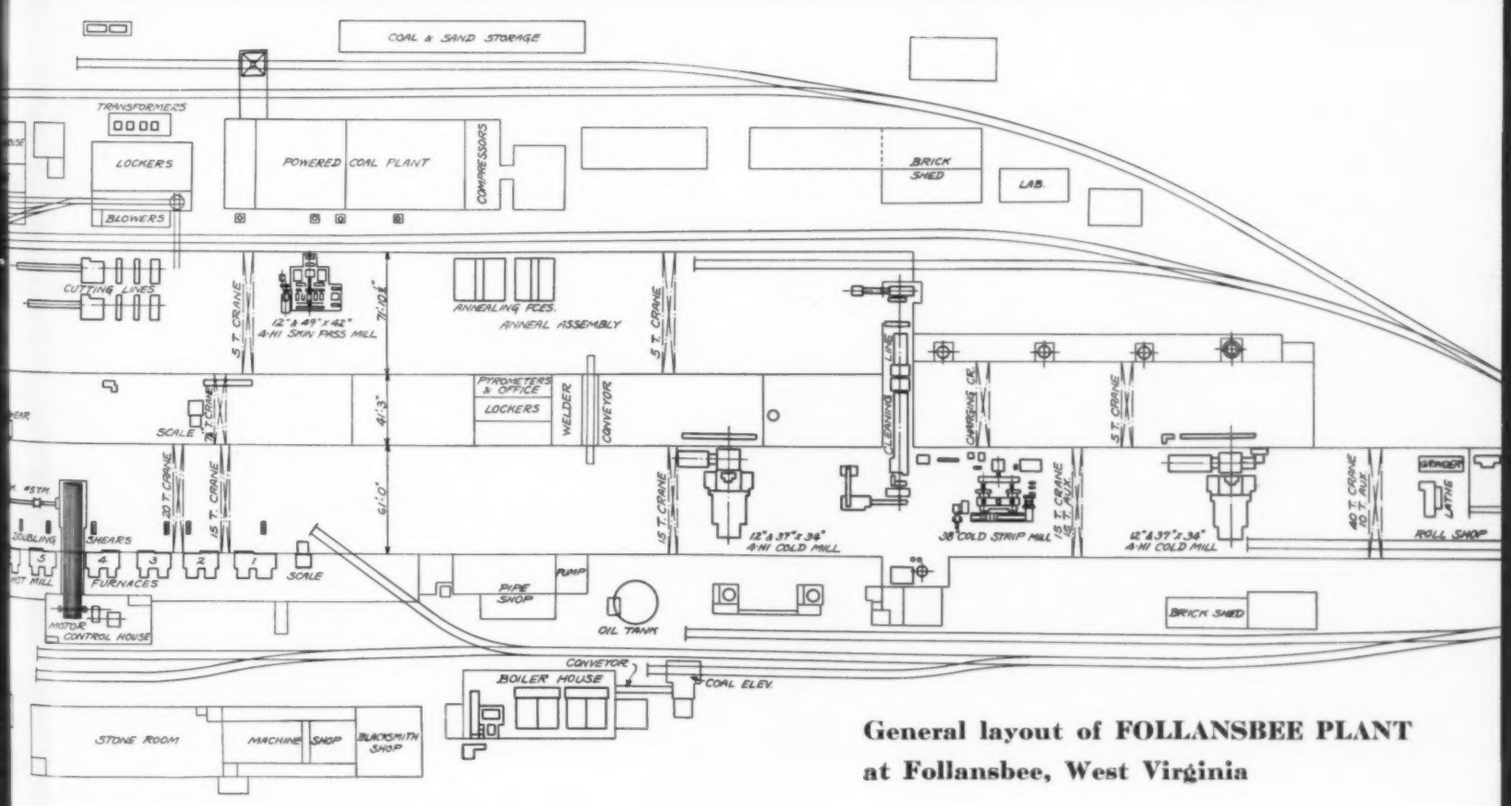
W. L. BARR
CHIEF ENGINEER

T. J. COSTELLO — GENERAL SUPERINTENDENT
SAM DAVIS — ASSISTANT SUPERINTENDENT
OPEN HEARTH, TORONTO WORKS

constant tension necessitates compensation for the WR^2 effect of the reels and the metal on them. The torque of the reel motors must therefore be varied directly as the coil diameter builds up. Special regulation is provided in each reel motor circuit, so arranged as to vary field flux of the reel motors in direct proportion to the reel build up. The reel motor field circuits are designed to give correct response throughout the entire speed range.

Each mill is controlled from two operating desks, which are used alternately depending on the direction of rolling. Mounted on each desk are the standard electrical gauges, screwdown indicators, wrap counters, etc.

Back-up roll bearings of each stand are lubricated by a circulating oil system, complete with pumps, tanks, filter, oil cooler, valves, alarms, thermometers, etc. This system is somewhat unusual, in that the pumps give constant (but adjustable) oil pressure, together with automatic variable volume control. Thus, the amount



General layout of FOLLANSBEE PLANT at Follansbee, West Virginia

J. T. THOMPSON

SUPERINTENDENT, FINISHING DEPARTMENT

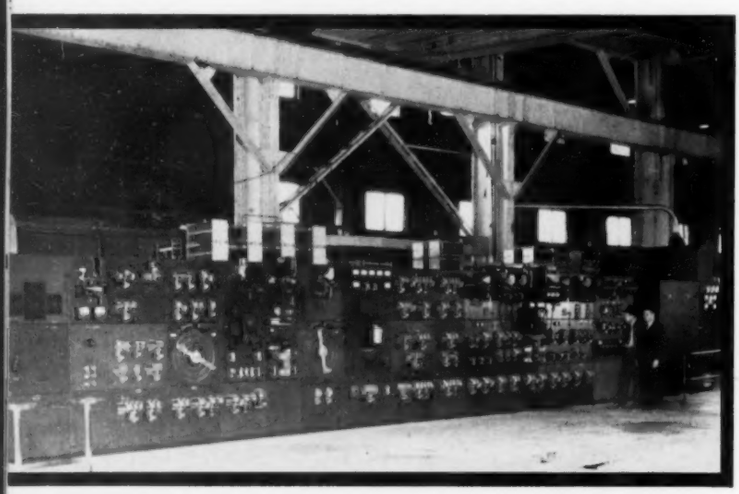
H. W. DAVIS

MANAGER OF QUALITY CONTROL

of oil pumped is the exact amount of oil passed through the bearings, which varies with the speed of the mill. By-pass relief, with its accompanying agitation of the oil, is eliminated, together with the necessity of safety valves and air-balanced pressure tank. Shut off valves anywhere in the system may be closed while the pump is running without any pressure build-up, no more oil entering the pump than the amount for which outlet flow is open. Complete shut-off results in maintained pressure, with no flow. A grease system serves work roll bearings on each stand. Another circulating oil system is provided for each pinion stand, and another grease system lubricates the screwdown meachanism. A coolant system is installed for each stand, consisting of two pumps, together with the necessary tanks, temperature control, etc.

A previously existing cold reduction mill, one of the early units installed for cold reduction of tin plate, is of the Steckel type, 8⅛ in. and 34 in. x 38 in., equipped with roller bearings. A single motor, 1000 hp., 400–800 rpm., 600 volts, operates through a double gear set of 7.0:1 ratio to drive the reels, which are 28 in. in diameter. The mill rolls are not driven. Delivery speed of the mill ranges from 420 to 1310 ft. per min. Power is furnished from a motor generator set consisting of a 750 kw., 600 volt generator, an 18 kw. exciter, and a 1090 hp., 2300 volt, 900 rpm. synchronous motor. The screwdown is driven by one 10–13.5 hp., 725–600 rpm., 230 volt d-c. motor.

The new mills are provided with complete, modern control systems. This board serves one of the reversing mills.

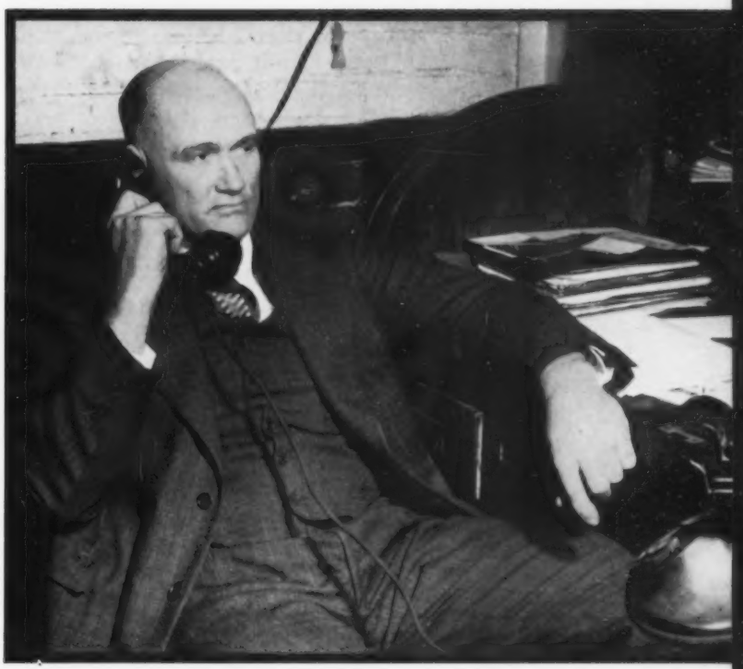


TEMPER MILL

Also a part of the recent building program is a four-high skin pass mill, 18 in. and 49 in. x 42 in. This mill, intended for skin passing material up to 36 in. wide at speeds of 1410–2350 ft. per min., is similar in general design to the reversing mills. The area of each housing post is 710.5 sq. in., while the housing windows are 55 in. x 15 ft. 3 in. Work rolls operate in roller bearings 8 in. x 12½ in. x 13¼ in., and back-up rolls run in 42 in. oil film bearings. Mill screws are 18 in. diameter and .40 in. pitch, and are driven through a reduction

P. J. MURRAY

SUPERINTENDENT OF MAINTENANCE, TORONTO PLANT



E. E. JACKMAN

CHIEF ELECTRICIAN

of 1025:1 ratio by two 35 hp., 575 rpm. motors, connected through a 24 in. diameter magnetic clutch.

Tension roll units are placed on both sides of the mill, each consisting of a pair of 20 in. x 42 in. chilled iron rolls mounted in cast steel brackets attached to the mill housing. Each roll is separately driven through a spur gear reduction.

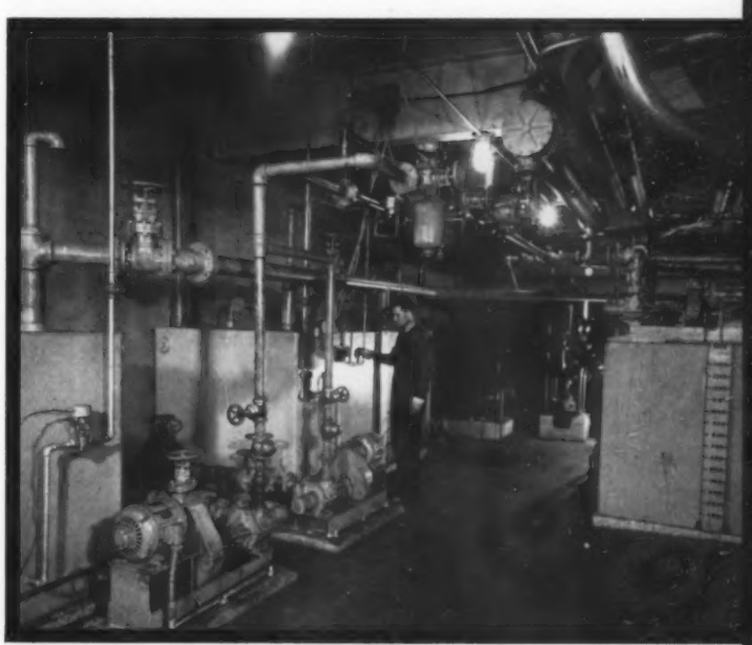
Entry of the strip into the mill from the adjustable tension feed reel is facilitated by 8 in. fibre discs which act as a top hold-down, a 10 in. deflector roll, and a bottom pinch roll, pneumatically adjusted.

The delivery reel is 20 in. x 42 in., built up of cast steel segments, with automatic strip gripper.

Drive units on the mill include one 600 hp., 300–500 rpm. motor on the mill rolls, two 150 hp., 600–1200 rpm. motors on the entry tension rolls, two 300 hp., 600–1000 rpm. motors on the delivery tension rolls, and one 150 hp., 450–1240 rpm. motor on the delivery reel. All of these motors are shunt wound, 600 volts, and receive power from a motor generator set composed of one 1000 kw. 600 volt main generator, one 60 kw., 250 volt delivery reel booster, and one 40 kw., 250 volt exciter, all driven at 720 rpm. by one 1500 hp., 2300 volt synchronous motor. An auxiliary motor generator set consists of one 3 kw., 125 volt pilot exciter for the reel booster, one 5 kw., 250 volt exciter for entry tension roll motors, one 7.5 kw., 250 volt exciter for delivery tension roll motors, and one 30 hp., 220 volt, 1750 rpm. squirrel cage motor. If desired, a 50 kw. entry reel drag generator may be added in the future, in which case another pilot exciter may be added to the auxiliary set.

The control system of the skin pass mill is, in general, similar to that of the reversing mills, except that reversing is not necessary. Tension is maintained by use of a constant current regulator which operates on the field

Lubricating systems serving the cold reduction mills include pumps of adjustable constant pressure, with automatic variable volume control.



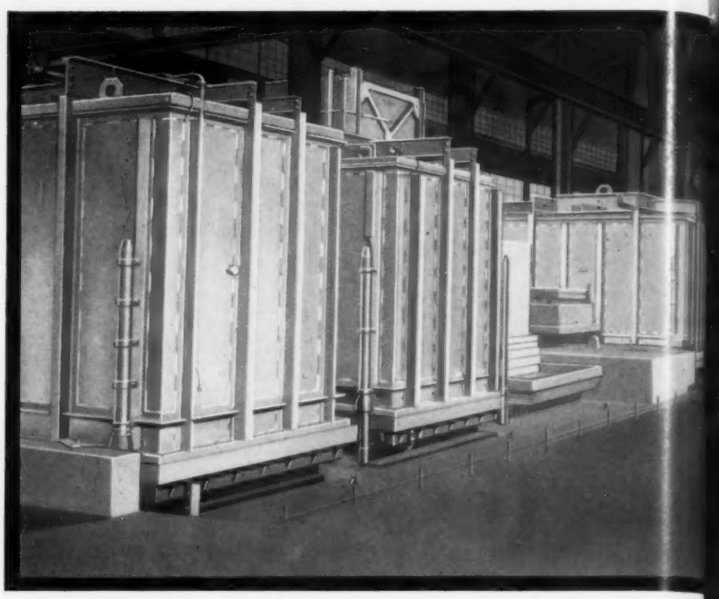
strength of the booster generator and keeps constant current in the reel motor circuit. Also, tension regulators are provided in the circuit, arranged so as to vary field flux of the motor in direct proportion to the change in reel diameter.

Another unit in the recent program is an additional flying shear line, designed to cut cold mild steel strip, .006–.03 in. thick and up to 30 in. wide, into lengths of 18–40 in. at speeds of 47–300 ft. per min. This unit includes a thirteen-roll, two-high roller leveler, pinch rolls, and guides. The shear is driven by a 25 hp. 1600 rpm., d-c. motor under variable voltage control. The shear is preceded by the feed roll, pinch rolls, and slitter and side-trim shear. This supplements a similar shearing line installed at the time of the first cold reducing mill but which has now been rebuilt and modernized to meet present exacting requirements.

TORONTO PLANT

All steel for electric sheets, as well as other products which are to be rolled from sheet bar, is produced in the open hearth department of the Toronto plant. There are four 45 ton furnaces, with hearth dimensions of 27 ft. x 12 ft., fired with fuel oil. The furnaces are charged by an overhead type charging machine, using about 50 per cent cold pig iron and 50 per cent heavy melting and bundled scrap. Limestone is added to the extent of about 9½ per cent of the metallic charge, little burnt lime being used. The time of heat averages 10¼ hours. tap to tap. Steel is usually tapped at .023–.027 per cent carbon, occasionally running up to .055 per cent for some needs, including alloy open-hearth steel.

Open hearth furnaces at the Toronto plant supply steel for billets and bars as well as for electric sheets.



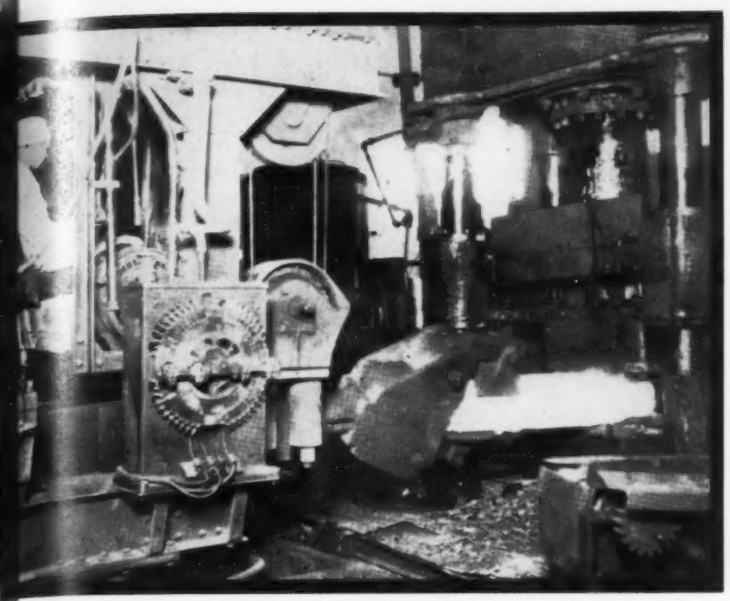
High silicon electric sheets are annealed at temperatures of 1875–1950 degrees F. in six bell-type electric resistor furnaces.

In the production of steel for electric sheets, tapping temperatures average about 2950 degrees F., and 50 per cent ferro-silicon is added in the ladle. On the higher silicon steels, some 75 per cent ferro-silicon is also used. Full ladles of steel are tapped so as to avoid phosphorus reversion due to contact between slag and metal. Steel is held in the ladle for a short time, and poured, at about 2850 degrees F., into 13½ or 14½ in. big-end-down moulds and 16 in. x 15 in. x 5 ft. 8 in. big-end-up moulds, which have previously been sprayed with graphite. Analyses of the steel produced for electric sheets are usually in the following ranges:

Silicon	.75 –4.50	per cent
Carbon	.025– .040	per cent
Sulphur	.019– .022	per cent
Phosphorus	.10 – .14	per cent
Manganese	.12 – .14	per cent

Ingots are subsequently reheated in four 32 ft. x 8 ft. in-and-out furnaces, fired with fuel oil, charged and drawn by a floor type revolving charger. After the proper heating cycle, the ingots are ready for hot working. Primary reduction is effected in a 1000 ton forging press operated by hydraulic and steam pressure. The ingot is transferred from the furnace charger over a roller table and scale remover, and is handled at the press by manipulators on either side. Ingots are forged, at temperatures not exceeding 2100 degrees F., depending on the grade, down to 6 in. x 6 in. billets. The forging operation gives a generally improved product, of uniformly high density, an important factor in the case of electric sheets.

The billets then proceed, at a temperature of about 1800 degrees F., to a two-high 30 in. reversing bar mill,



Ingots produced at the Toronto plant are broken down into blooms or billets on a 1000 ton forging press.

where they receive seven passes and are reduced to sheet bar 8¼ in. wide and .350–.650 in. thick. The bar mill is driven by a 2200 hp., 700 volt, 0–50–100 rpm. reversing motor. This motor is served by a flywheel motor generator set composed of one 1650 kw., 700 volt d-c. generator and one 1600 hp., 2200 volt, 500 rpm. induction motor controlled through a liquid slip regulator.

The production rate of the press and bar mill averages about 20 tons per hr. The Toronto, Ohio, plant of Follansbee Steel Corporation, in addition to furnishing sheet bar for electrical sheets, supplies forged billets and bars of carbon steel and alloys for regular commercial and special needs. The open hearths, ingot heating furnaces and 1000-ton forging press can produce forged blooms up to 12½ in. square and up to 4200 lb. each. The 30-in. reversing bar mill produces 8 in. x 6 in., 6 in. x 6 in., and 4 in. x 4 in. rolled sections from forged billets.

The Toronto plant also includes two trains of hot sheet mills, together with the pickling, annealing and other processing equipment necessary for sheet production. At the present time, however, these mills are not operated, all sheet rolling being done at the Follansbee plant. Considerable annealing is performed at Toronto, particularly on the higher silicon grades of electric sheets. For the 4½ per cent silicon grade, six bell type electric resistor furnaces are used, with piling dimensions of 10 ft. 3 in. long x 3 ft. 10 in. wide x 60 in. high. Furnace charges average about 20 tons, and the annealing cycle may range 85–105 hr. heating, 24–34 hr. soaking, and 90–105 hr. cooling. Temperatures range between 1875 and 1950 degrees F., and are under automatic control. About 650 kwh. are consumed per ton of sheets annealed, and the furnaces afford a capacity of approximately 500 tons per month. A special annealing atmosphere of nitrogen is used, being furnished from an 800 cu. ft. per hr. dissociated ammonia combustor and two 8500 cu. ft. per hr. circulating fans. Improvements in the design and control of furnaces of this type have improved the general quality of the annealed

RICHARD GRAHAM
MASTER MECHANIC

G. D. SMITTLE
MASTER MECHANIC, TORONTO PLANT

W. R. BOBEY

SUPERINTENDENT OF COLD STRIP MILL

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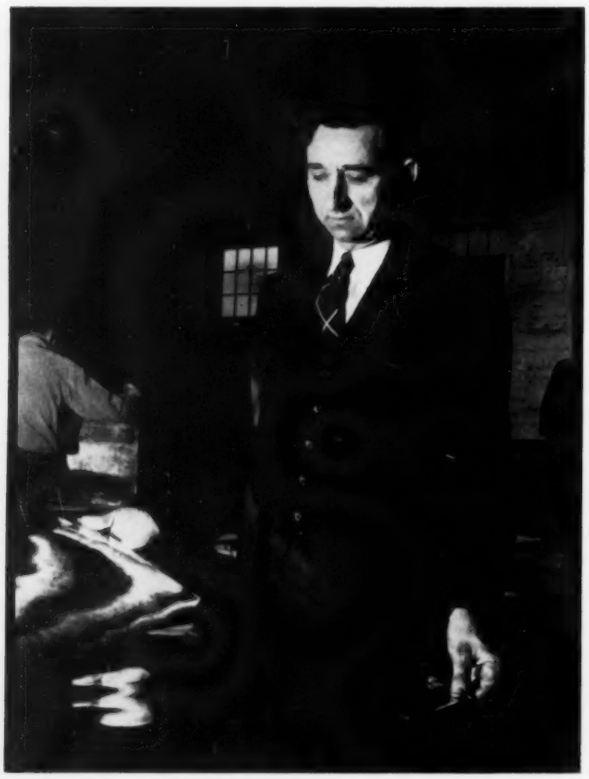
STANLEY DUSKEY

SUPERINTENDENT OF TINHOUSE



product, especially as to flatness, surface, and electrical characteristics.

There are also two continuous annealing tunnel furnaces, 272 ft. long, fired with natural gas. Some lower silicon sheets (¾–1¼ per cent silicon) are annealed in these furnaces, using temperatures of 1450–1500 degrees F., with cycles of 60–70 hr. heating, 24–32 hr. soaking, and 56–70 hr. cooling. Charges average about 20 tons per box, with 19 to 21 boxes simultaneously in each furnace.

SHEET PRODUCTION AT FOLLANSBEE

Sheet bar from which electric sheets are to be rolled are shipped to the plant at Follansbee where they are hot rolled on hand mills using the single mill system. Each of the two hot mill trains is driven through a rope drive by a 1500 hp., 2300 volt, 514 rpm. wound rotor induction motor. Two finishing mills are provided with automatic feeding and catching equipment, and are supplied from chain type continuous heating furnaces; two roughers also have continuous furnace equipment. The remainder of the furnaces are of the in-and-out batch type. Conventional hand mill practice is followed, with the silicon steels using a somewhat higher rolling temperature than the general grades, running up as high as 1800 degrees F. Silicon steel increases in brittleness as the silicon content increases, and may crack if rolled at low temperatures. Electric sheets run No. 22 to No. 29 gauge, although some 16 gauge is rolled for d-c. pole applications.

Finishing equipment at Follansbee includes one rocker type sheet pickler; one gravity type coil pickler handling wrapped coils up to 100 ft. in length; one continuous cleaning line; eight portable annealing covers; twenty-seven in-and-out annealing furnaces; fifteen stands of conventional cold mills, arranged two and three stands in tandem, as well as single, driven by one 500 hp. and one 200 hp. motor, both 2200 volt, 514 rpm., synchronous; one white pickler; eight tin pots, five terne pots, and two long terne pots.

The pickling of silicon sheets, with acid strengths of 12–14 per cent and a temperature of about 190 degrees F., requires approximately 50 per cent longer time than regular grades. Annealing temperatures range from 1125 to 2000 degrees F., depending on the grade of the material and its processing. Cycles range from 60 to 240 hr. In the portable covers used for tin plate annealing, charges average about 34 tons, while the in-and-out charges are approximately 19 tons. Seven of the latter type furnaces have been modernized, using gas firing and automatic temperature control. Sheet cold rolling effects a reduction of about ½ per cent, and some material is cold rolled in water.

Electric sheets produced by the conventional hot mill process carry a film of surface oxide which in some cases is desirable, acting as an insulator between the laminations. Such films, however, must be tight, as loose scale will cause trouble in subsequent punching and shearing operations. Scale from the higher silicon grades is particularly abrasive, and very damaging to dies and shears. Therefore, high silicon sheets are often pickled after hot rolling, whereas the lower silicons are not.

In many cases, the surface oxide which is produced on electric sheets by modern annealing atmospheres is entirely satisfactory without any additional coating. When necessary, however, core plating, consisting of coating full size electrical sheets or laminations with a very thin covering of varnish or similar material, is done in a continuous oven, varnish being applied as the material passes between rolls. The varnish is then flashed on in a gas-fired oven at temperatures of 450–850 degrees F. One type of coating used is a heat-proof enamel, for sheets which are to be later annealed at temperatures not exceeding 1450 degrees F. Another coating consists of an oil-proof varnish, either amber or black, generally flashed on material to be used in oil immersed cores and rotating apparatus. Coatings are applied so as not to reduce the space factor more than 1 per cent. Such coatings increase die life and generally improve die performance in subsequent stamping operations.

The higher silicon steels, over 4 per cent and in heavy gauges, are quite low in ductility. These grades require sharper shears and dies, with good clearance in the punches, while the lower grades (2½ per cent or less silicon) do not require as much punching clearance.

From the foregoing, it is evident that two separate and distinct manufacturing processes are carried on. The newly installed cold mills give facilities for the production of cold-reduced tin plate, black plate, terne plate and blued sheets by the modern method. For this product, steel is purchased in hot rolled and pickled coil form. The hot sheet mills are used for the production of all electric sheets and for various other special sheet items. The steel for these sheets is made in the company's own open hearth furnaces at the Toronto, Ohio, plant.

ED HURL

SUPERINTENDENT, CLEANING AND CUTTING LINES

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O. ZENOBILE

SUPERINTENDENT, ANNEALING DEPARTMENT

QUALITY CONTROL

A very close watch is maintained on all phases of quality control, and every precaution is taken to insure close, uniform compliance with the customer's requirements, many of the grades being "tailor-made." The general laboratory checks each order for pertinent characteristics as it leaves each department. This laboratory is equipped with complete facilities for all necessary tests, including Erichsen, Ohlson, Rockwell, tensile, core loss, space factor, permeability, inter-lamination resistance, and microscopic analysis. Chemical determinations are also made on product and on raw materials. In testing for electrical properties, four sheets are taken from various points in each lift (7000–8000 lb.) after the final annealing process. These sheets are then used for Erichsen, core loss, permeability, space factor, and inter-lamination resistance tests. Additional testing and checking facilities are provided in the tin house laboratory, devoted principally to checking tin plate and the materials entering into the tinning process.

Another product of considerable interest is roll terne roofing, which is similar to the usual terne plate except as to its length. Production methods have been developed by which terne coating may be done continuously, resulting in strip lengths, up to 100 ft. or more, of terne plate. This material is produced by cold reduction of copper-bearing strip to the desired gauges (averaging

ADVERTISING PAGES REMOVED

about .011 in.), followed by a dead-soft anneal, temper rolling, cleaning and scrubbing, side trimming, roller leveling and shearing to the required lengths. These lengths are then pickled in coil form in the continuous gravity pickler previously mentioned. After a thorough washing, the strip is passed through a flux bath into the molten terne mixture, through a special automatically controlled coating machine and an oil bath, and is cooled, cleaned, leveled and finally recoiled. After inspection and painting, the rolls of terne roofing are ready for shipping in special containers. These long lengths of roofing stock eliminate cross seams in roof construction, with consequent ease of application and reduction of maintenance.

POWER SUPPLY

For the Toronto plant, all power is generated in the plant power house, which contains two 3000 kw. and one 1500 kw. turbo-generator units, all 2300 volts, 3 phase, 60 cycle, 80 per cent power factor, and equipped with surface condensers. Steam is supplied to these units and to general plant usage from six 660 hp., 200 lb., 100 degrees superheat water-tube boilers, equipped with under-feed stokers. Power is distributed to the various departments at 2300 volts over 500,000 circular mil weather proof conductors. Direct current for mill auxiliaries is supplied by one 500 kw. and two 360 kw., 250 volt motor generator sets.

At the Follansbee plant, all power is purchased from the utility company serving the district. Power at 25,000 volts is brought to an outdoor sub-station consisting originally of six 1000 kva., 25,000/2300 volt single phase transformers. In connection with the recent expansion, it was necessary to add to the substation three new single phase transformers, each of 2000 kva., 25,000/2300 volts, making a total incoming transformer capacity of 12,000 kva. The 2300 volt power is distributed from the main switch board in the nearby plant power house to the consuming departments.

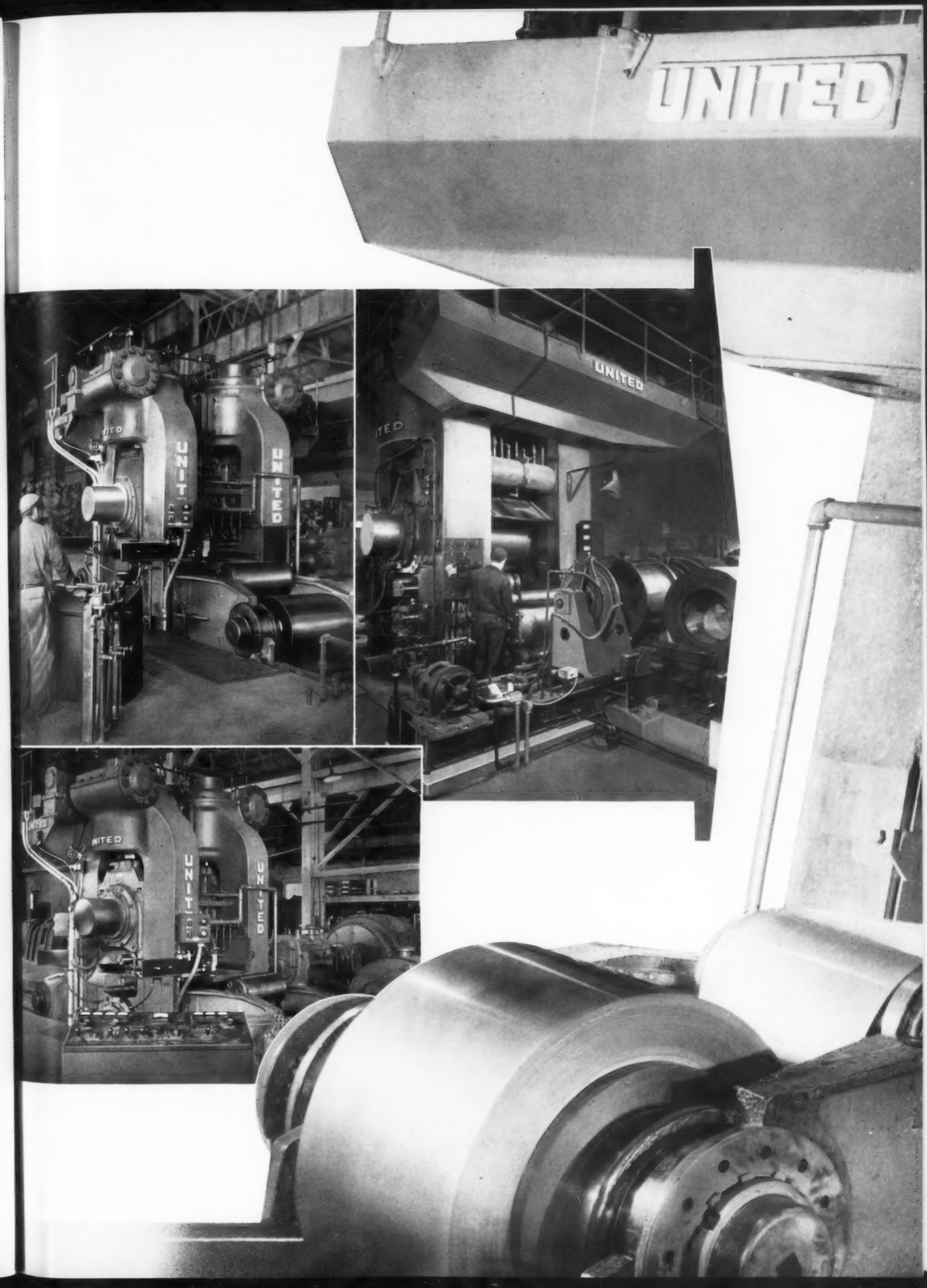
CHARACTERISTICS OF ELECTRIC SHEETS

Grade	Yield point, lb. per sq. in.	Ultimate strength, lb. per sq. in.	Elongation, per cent in 2 in.	Guaranteed core loss, watts per lb. at 60 cycles, 10,000 lines (1)	Safe permeability values at 14,000 lines (2)	Minimum space factor, per cent	Approximate silicon range, per cent (3)	Properties	Typical application
Armature electric grade	25,000	45,000	25	1.55 (26 ga.)	1500	96	.50– .65	Excellent ductility; high magnetic permeability at high densities.	Intermittent duty rotating equipment. Moderate efficiency where low core loss is not a factor.
Improved electric grade	30,000	50,000	20	1.35 (26 ga.)	1200	96	.90–1.10	Excellent magnetic properties; very good physical characteristics.	General purpose a-c. and d-c. motors of small to moderate size.
Special motor grade	50,000	67,000	15	1.14 (26 ga.)	950	96	2.25–2.50	Moderate loss; excellent punching qualities; very good magnetic properties.	Moderate size rotating machines; radio transformers; control apparatus.
Special dynamo grade	55,000	75,000	12	.94 (26 ga.)	850	94	3.00–3.50	Low loss; very good punching qualities.	Large and medium size induction motors, generators, small transformers, control apparatus, radio transformers.
Regular power transformer grade	65,000	80,000	10	.72 (29 ga.)	737	94	3.90	Good stamping properties, good permeability at low flux densities.	Instrument and radio transformers; large high efficiency generators, motors, and synchronous condensers.
Special power transformer grade	62,000	73,000	8	.65 (29 ga.)	666	94	to		
Extra special power transformer grade	65,000	75,000	4	.58 (29 ga.)	609	94		Very low core losses consistent with shearing requirements; high maximum permeability.	Distribution and power transformers.
Transformer 52 grade	68,000	70,000	2	.52 (29 ga.)	560	94	4.50		

(1) Values obtained in practice are materially lower than those tabulated.

(2) Permeability values may be modified by suitable processing in order to meet customer's requirements at other densities.

(3) These ranges are varied to suit the customer's requirements.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Meet the Equipment Manufacturer

THE ELECTRIC CONTROLLER & MFG. CO.

With this issue is presented the first in a series of articles outlining the history and development of the many companies servicing the iron and steel industry. It is felt the progress of the equipment manufacturer has been so closely allied with the upward march of the steel industry that our readers would be interested in the many developments sponsored by the manufacturer which were so helpful to the industry. In later issues this series will be continued.

▲ IN the 1890's, steel mill electrical superintendents were beginning to change auxiliary drives over from steam to electric power. One of the first advocates of this practice was A. C. Dinkey, then electrical superintendent of the Homestead Works of the Carnegie Steel Company—later, president of this company and then of the Midvale Steel Company, of Philadelphia, Pennsylvania.

Being unable at that time to get a controller that he thought was suitable for steel mill work, Mr. Dinkey invented a controller for this service. Crane builders who furnished cranes, charging machines, etc., for the Homestead Works were furnished drawings of Mr. Dinkey's controller, and these machines were the first that were equipped with the Dinkey controller.

In 1897, the Electric Controller & Supply Company was organized in Cleveland, Ohio, to manufacture this controller. A small factory space was rented near downtown Cleveland, and in a few years the company moved to larger quarters in the vicinity of its present location. The next move was to 2700 East 79th Street, the present location of the company which is now known as the Electric Controller & Manufacturing Company.

During the next five years, this company spent considerable time in the development of a lifting magnet for handling scrap and pig iron and, in 1904, received recognition at the St. Louis World's Fair for building the first successful commercial scrap, pig-iron and steel handling magnet in the world. This invention was considered by many at first to be merely an "inventor's dream" incapable of standing up in steel mill service, but once convinced, this dream proved to be a very useful necessity throughout the iron and steel industry. Since that time, lifting magnets have been applied to practically every type of magnetic-handling problem and also have been used for road-sweeper service to remove nails, tacks and other puncture-producing material from roads, streets and highways.

BLUE RIBBON AWARD WORLD'S FAIR 1904

At the same World's Exposition, the EC&M Co. received a blue ribbon award for a controller used on a reversing motor-driven planer which was stopped by dynamic braking. At that time, the interpole motor had not yet been developed and to obtain satisfactory speed control of the motor, a 115/230 volt power circuit was employed to give the desired results.

As controllers for electric drives were applied more universally, there arose a demand for magnetic contactor control which provided remote control of the motor from a small master switch located within easy reach of the operator, either in a crane cab or in a mill pulpit. The need for magnetic control was particularly important as the size of motor with which the controller was used increased. In perfecting the design of a magnetic contactor, an EC&M engineer one day discovered a means to combine a contactor and an acceleration relay. This was the series switch which served to make automatic control more economical and provided many new uses for electric motor drive. One major application for the series switch control was in connection with machine tool drives, in which the machine operator was provided with complete control from a small master switch within easy reach on the machine; the large controller being mounted at a remote point. From this small master switch, the operator was able to start and stop the machine at will. In addition, the control in many cases permitted him a choice of allowing the machine to drift to rest or to be brought to rest quickly by dynamic braking.

In 1912, about fifty electrical superintendents, many of them members of the Association of Iron and Steel Electrical Engineers, were invited to Cleveland, Ohio, to visit the plant of the Electric Controller and Manufacturing Company to witness the first demonstration of dynamic lowering hoist control for direct current cranes. This development marked a new era in crane control, eliminating as it did, the troublesome and expensive-to-maintain load-brake which had, heretofore been necessary to prevent overspeeding when lowering heavy overhauling loads. In 1930 when D. C. Wright, chief engineer of this company, developed the Wright dynamic lowering circuit for crane hoists, the new circuit not only gave instantaneous brake release, permitting accurate spotting of heavy loads, but also gave a greater power-return to the line and

at the same time, used less power from the line on first point lowering, thereby reducing wear on contactors and likewise reduced heating on the motor.

As the size of cranes for handling ladles and similar applications increased, the trend was toward the use of two or more smaller motors connected to the same shaft to drive the load. This meant the elimination of very large motors, keeping them to a size in which the same spare motor might be used for either crane or mill service; and also facilitated not only the original installation of the motor, but made it easier to change the smaller motor in case of trouble. This method of operation introduced a problem in control which would insure that both motors be started and stopped simultaneously and accelerated uniformly; otherwise there would be an unbalancing of the load during acceleration and if one motor stopped before the other, the remaining motor, while continuing to run, would tend to rise on its gear which had been brought to rest by the other motor through the connecting gears and result in shearing off the bearing bolts. Presented with this problem, EC&M engineers developed duplex control, consisting of double pole contactors for main, reversers and acceleration points with a single train of acceleration relays. With this system of control, the motors are operated like one single motor; each motor taking its share of the load while running, and both motors being started and stopped simultaneously.

INTRODUCTION OF YOUNGSTOWN SAFETY LIMIT STOP

A suitable line of accessory equipment for cranes became necessary as crane operation was improved and about 1915, EC&M started the manufacture of Youngstown safety limit stop, the first limit stop which not only disconnected the motor from the line but brought it to a quick stop by dynamic braking. A crane protective panel for the protection of all motors on a crane was soon in demand and EC&M was one of the first to manufacture an item of this type. Further refinement has been added in recent years in the form of a heavier duty contactor, a more substantial enclosure and a more convenient method for padlocking the enclosure against tampering by unauthorized persons.

Industries were expanding quite rapidly in the early 1920's and many drives which ran continuously from morning till night were operated by the a-c. squirrel-cage motor which received little or no attention as long as the motor ran. An accurate watchman was needed to avoid motor burnouts due to an overloaded condition or operation on single phase power as the result of a blown fuse. EC&M introduced the hot-wire, thermal type of overload relay for this service. Applied not only on the full voltage but on the reduced voltage, compensator-type starter as well, this Thermal Relay quickly won wide recognition as a sensitive device in reducing motor failures.

In 1929 following many years in which current-limit and time-limit methods of acceleration were employed for automatic acceleration, EC&M introduced time-current control. As its name implies, this system of control combined all the advantages of both of the previous systems and enabled the motor to get under way slowly on Monday mornings when first starting up with the gear grease cold and as the mill warmed up, automatically shortened the time until the mill was attaining high speed production. Used on cranes, this control enables the operator to take the swing out of the load by permitting very fast acceleration when the motor is aided by the load

F. R. FISHBACK . . . *(right)*
Rose Polytechnic Institute, 1902... first job in repair shop of railroad company . . . joined company as draftsman . . . then was salesman, district manager, sales manager, vice president and elected president in 1925.

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R. G. WIDDOWS . . .
University of Pennsylvania . . . with company 31 years . . . has been district manager New York office and sales manager from 1924 to 1939 . . . from that date, vice president.

as the bridge or trolley is to be quickly centered over the load at the point of discharge.

At the Iron and Steel Exposition held at the Wm. Penn Hotel, Pittsburgh, in 1935, EC&M exhibited a development that created outstanding interest, drawing nearly everyone who attended the show to the EC&M booth to witness the demonstration of a new contactor, the line-arc contactor. The exhibit consisted of a standard 100 ampere contactor, fitted with special arc shields made of glass so that the arc as it was extinguished might be readily observed during the handling of loads as high as 300 per cent of capacity. Of unusual interest to observers was the fact the contactor, in closing against 300 amperes, showed no arcing or sparking, indicating that bouncing which had heretofore been responsible for welding of contacts in many cases had been eliminated. Line-arc contactors have outlasted all previous design of magnetic contactors on the hardest worked jobs found in steel mill service. In many instances these contactors are still working with the original contacts and arc shields.

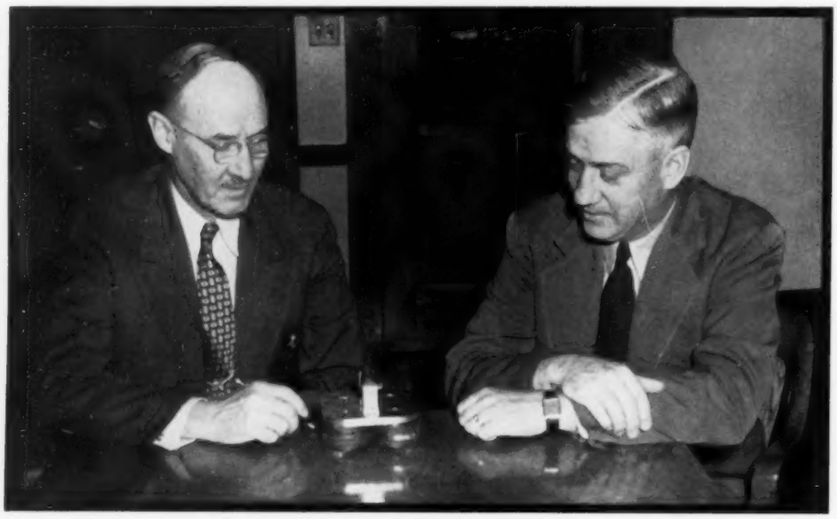
In 1938, EC&M introduced two new methods of acceleration: Frequency relay magnetic control for alternating current wound rotor motors, in which frequency relays are used for acceleration, speed-limiting and for removal of the reverse-power contactor on quick-stop-by-plugging controllers, and Neo-time control for use with either d-c. or a-c. motors. Neo-time control is a simple method for providing definite-time acceleration which can be readily adjusted to suit requirements by turning a small dial-switch. It is especially applicable to heavy-inertia drives requiring long-time acceleration. In these cases, practically any desired time may be provided. This method of timing has also been used as a timing-panel for blast furnace distributor top motors, in which the Neo-timer, mounted at ground level, replaces the limit switches normally mounted at the top of the furnace, thereby eliminating the necessity of maintaining electrical equipment in this dangerous area.

For use on alternating current systems, EC&M has also developed a time-current method of control, known as Neo-time-current. It has the advantage of automatically lengthening or shortening the time depending upon the load on the motor. Used as a means for applying the direct current power to the field of a synchronous motor, Neo-time-current control has the advantage of allowing the motor to practically pull into step as an induction motor with field being automatically applied at the instant that maximum speed is reached. If the load on the motor is heavy during acceleration, longer time is allowed and if the motor attains full speed more quickly under a light load, the time allowed before the field is applied is automatically shortened, so as to put the motor into synchronism in the shortest possible time.

In 1939 at the annual Iron and Steel Exposition of the Association of Iron and Steel Engineers, EC&M astounded the electrical industry by demonstrating the first a-c. dynamic lowering control for alternating current hoists operated by wound-rotor motors. This exhibit consisted of a standard wound-rotor motor connected through suitable gearing to a cable-drum with cable passing over a sheave on top of a 23 ft. tower. Loads consisted of a magnet representing about 125 per cent load on the hook and a small weight equivalent to about 20 per cent load. Only alternating current power was used and was supplied to the motor through a controller using standard contactors, relays and master switch. First point lowering gave a very slow creeping speed and it was possible to obtain short, accurate, inching movements of the heavy magnet load. Several of these controllers are now in service in steel mills, railroad shops, shipyards, metal-working plants and roll-grinding shops. On one crane of 25-ton capacity, the operator claims greater accuracy in setting a 33-ton annealing furnace top in position with the new a-c. dynamic lowering control than he has ever had before.

With frequency relay magnetic control for the bridge and trolley motions of standard overhead cranes and a-c. dynamic lowering control for the single-motor hoist and frequency relay counter-torque control for the 2-motor bucket-hoist, EC&M has provided accurate and refined control for the alternating current crane. This gives industry an opportunity to obtain successful operation from the a-c. crane in places where direct current is not available and where the cost for a conversion unit and its enclosure is prohibitive in proportion to the total expense for the new addition or new enterprise.

Last year, the EC&M Company celebrated its fortieth anniversary and during this 40-year period, has been very active in the promotion of new electrical equipment that permits better steel to be made at lower cost. From a small beginning, the company has grown to be one of the major control manufacturers.



A. C. DYER . . . *(right)*
Carnegie Institute of Technology . . . then West Penn Steel Co., Allegheny Steel Co., and Homestead Works of Carnegie-Illinois . . . 1913 to 1916, salesman in Pittsburgh office . . . district manager from 1916 to 1939 . . . since that time, sales manager.

D. C. WRIGHT . . .
Harvard University . . . with the company before graduation (working during summer vacations) after graduation started in engineering department in 1904 . . . has been chief engineer and secretary of the company since 1925.

AMERICAN ROLLING MILL COMPANY WILL BUILD NEW STEEL PLANT NEAR HOUSTON, TEXAS

▲ American Rolling Mill Company recently announced that a steel plant would be built on the ship canal near Houston, Texas. A Texas corporation will be organized to build the plant, which will be a wholly-owned Armco subsidiary. Operations of the new plant will be managed by the Sheffield Steel Corporation, another Armco subsidiary which operates plants in Kansas City and St. Louis, Missouri, and Tulsa and Sand Springs, Oklahoma. The production of the new plant will not be competitive with the iron and steel products now produced by the American Rolling Mill Company, but will be similar to those now manufactured by the Sheffield Steel Corporation. The new steel plant will manufacture billets for shell forgings, structural steel, light plates for shipbuilding, wire, rods, oil field supplies, and other items necessary to national defense.

The capacity of the plant will be modest with respect to the total production of products consumed in the area to be served. This will prevent any disturbance of the normal competitive conditions in the area, and will permit the permanent operation of the plant after the emergency is over. Consisting of three 100-ton open hearth furnaces, a billet mill, a rod mill, merchant bar mill, 84 in. plate mill, wire mill, and auxiliary equipment, the plant will have an estimated annual capacity of 200,000 ingot tons.

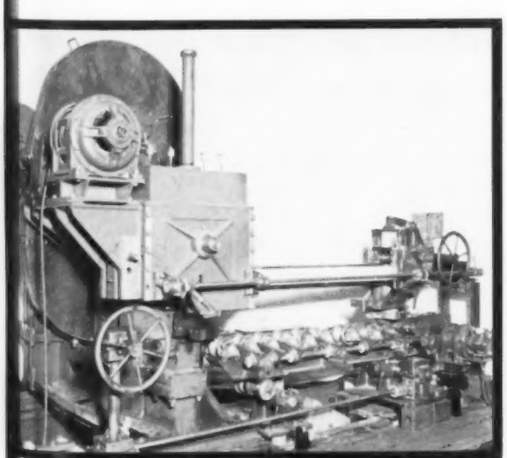
The option of 600 acres located on the Houston ship canal is being closed, which will permit the loading of ocean-going vessels from the docks of the company.

DEVELOP NEW SHEAR FOR ALLOY BILLETS

▲ The problem of shearing alloy steel billets finds a new and economical solution in a vertical type hot billet shear developed by Lewis Foundry and Machine Division of the Blaw-Knox Company. The shear is a self-contained accessory which is readily inserted into the production line. It cuts downward, across the diagonal, and there is less deformation of the billet stock by reason of this diagonal shearing action. Complete control from a central point permits one man operation of both shear and runout table, and the operator also retracts the table for discharge of the crop ends. The first unit built accommodates sizes up to and including 4½ in. square, and the design is adaptable to larger sizes.

Power for the shear is provided by a 40 hp. motor, transmitted through a double reduction gear drive, which drives a main crankshaft of 7 in. stroke. The shear is actuated by a one-revolution clutch—a mechanical assurance of safety. By stepping on the foot treadle, the operator—by means of the one-revolution clutch—places the shear in motion for one cut only. The runout table is powered by a 5 hp. motor, which, however, serves two functions. In the one direction, it drives—through an overrunning clutch—the rollers of the runout table; in the reverse direction, the table motor—through another overrunning clutch—operates the kickoff fingers. The operations in each cycle are governed by limit switches, which in turn are controlled by the operator's handling of the main and secondary stops on the table gauge.

This new shear, which is readily inserted in the production line, is a new and economical solution of the problem of shearing hot alloy steel billets.



COLUMBIA STEEL EXPANDS PRODUCTION FACILITIES

▲ Columbia Steel Company, a subsidiary of the United States Steel Corporation, recently announced a program for the enlargement of its facilities involving an expenditure of over $5,000,000. It was declared that the decision to build further steel making and finishing mill facilities on the Pacific Coast at this time is a recognition of growing steel demands of that region coming from manufacturers engaged in national defense work, as well as from other users of steel products.

Acquired by the United States Steel Corporation in 1930, the Columbia Steel Company is a fully integrated company owning and operating steel works at Pittsburg and Torrance, California; ore and coal mines and a blast furnace in Utah; open hearth furnaces with a 1939 annual capacity of 290,000 net tons; rolling, wire, nail, sheet and tin mills at the foregoing California locations; foundries, and a

wire rope and fence plant at San Francisco.

At the Utah plant, located at Ironton, are 56 by-product coke ovens with an annual capacity of 193,000 tons of coke, a coal mine with 536,000 tons annual capacity and a blast furnace of 172,000 tons annual capacity of pig iron. Annual capacity of iron ore operations at Columbia, Utah, is 360,000 tons.

DEVELOP FIREPROOF TRANSFORMER LIQUID

▲ A new type transformer known as the Wagner "Noflamol" transformer has been developed by the Wagner Electric Corporation. The new transformers are filled with a non-inflammable synthetic liquid developed as an improvement over regular transformer oil. Because of the non-inflammable characteristics of this liquid, these transformers can be installed indoors without the use of fireproof vaults.

LARGE GENERATING UNIT FOR GRAND COULEE DAM

▲ The world's largest waterwheel generator purchased for the Grand Coulee power project, on the Columbia River in Washington, was built in the East Pittsburgh shops of the Westinghouse Electric and Manufacturing Company. This giant 108,000 kw. machine, first of three being built for the power project, is scheduled for installation in the West Power Station of the dam, and is expected to be ready for operation next summer.

The machine weighs almost 1000 tons, is 24 ft. high, and 45 ft. in diameter, and consequently had to be shipped part by part across the country. Shipped by railroad over twelve different railroad systems, the generator required thirty-eight freight cars and consumed eleven days' traveling time.

The three generators required some 2255 tons of steel, and when completed will have utilized over one million man-hours of work. The two other machines are now under construction, the second to be shipped this spring, and the third to be delivered during the coming summer. All of the generators are scheduled for operation by the spring of 1942.

Each of these three new generators, rated at 108,000 kw. apiece, have a power capacity thirty per cent greater than any other waterwheel generator ever built in the United States. Their combined capacity would be sufficient to light the cities of New York and Chicago at the same time. When completely installed the generators will help furnish power to drive six 65,000 hp. motor driven pumps, each pump capable of lifting 12,000 gal. of water per sec.

REPUBLIC TO INSTALL BLAST CONDITIONING

▲ Republic Steel Corporation will install air conditioning equipment on one of its two blast furnaces at the Thomas Works in Birmingham, Alabama. When the installation is completed, in about three months, four blast furnaces in the Birmingham district will have been provided with modern air-conditioning equipment.

In announcing the new installation, Republic stated that the moisture in the air in Birmingham varied from eleven grains to about two grains per cu. ft. and the equipment to be installed at the Thomas Works will make it possible to blast the furnace with uniform moisture content in the air. This content will approximate three grains per cu. ft. The refrigerating equipment will be driven by steam turbines, operating at high speed.

A description of the various applications of air conditioning to blast furnaces appeared on Page 73, IRON AND STEEL ENGINEER, December, 1940.

NEW TRUCKS EMPLOY GAS ENGINE POWER

▲ A lifting, carrying, tiering fork truck that will handle loads as heavy as 7000 lb., and tier them in piles 15 ft. high and higher, has been introduced by Clark Tructractor Division of Clark Equipment Company under the name "Utilitruc."

This truck is said to be particularly efficient in car loading and unloading operations, in utilizing storage capacity to the full by high stacking and in serving production machines with materials and parts from storage. Gas-powered, it is capable of 24-hr. continuous operation.

Utilizing gas engine power, this new truck is capable of 24 hr. continuous operation. It is particularly efficient in car loading and unloading operations, using storage capacity to the full by high stacking of materials.

This new finger truck is made in several models including straight lift, tilting and telescopic tiering. Minimum height is 61½ in., enabling the truck to negotiate low doorways. Minimum capacity is one ton. Heavy steel fingers, with chisel points, vary in length and are adjustable sidewise on the front plate. The operator inserts these fingers under any cleated or uncleated load, lifts the load clear of the floor, tilts it back 10 degrees in one sec. for safe riding, elevates it at the rate of 7 in. per sec., tilts it forward 3 degrees in ½ sec. for easy tiering.

The machine is powered with a six-cylinder heavy duty tractor type motor, travels at speeds from 1 to 7 mi. per hr., climbs ramps under load, has rear wheel steer, hydraulic brakes. The lifting unit is powered with a hydraulic vane type oil pump driven by special direct drive from motor and runs constantly at two-thirds engine speed.

LUKENS PLANS LARGE EXPANSION PROGRAM

▲ Lukens Steel Company at Coatesville, Pennsylvania, was awarded $2,160,000 by the U. S. Navy Department for extension of the heating facilities in the 206 in. plate mill. This mill is being called upon by the government for large quantities of wide plates which are used in the construction of hulls of submarines, as well as for the heads for boilers of naval vessels. In addition, the mill rolls large tonnages of wide, thick, or heavy plates for other concerns manu-

facturing national defense equipment for the navy. One division of Lukens, Lukenweld, Inc., uses plates from this mill in the manufacture of gun mounts for anti-aircraft guns, while the other division, By-Products Steel Corporation, makes component parts for Lukenweld and many other government suppliers.

Included among the changes which will be made in the 206 in. mill unit is an extension to and strengthening of the present heating building to increase charging facilities in the soaking pits, as well as to permit the handling of heavier ingots and plates. The mill's shear building will be extended and strengthened to handle a larger volume and heavier material. Four new heating furnaces, with necessary cranes, and an ingot chariot for transferring the heated steel to the mill for rolling, will be installed.

All design and construction work will be handled for the Lukens Steel Company by Arthur G. McKee and Company. Practically all plans have been completed and construction is expected to start shortly.

NEW WATER FILTER USES RADIAL FINS

▲ Many engineers will be interested to learn that radial fin construction, successfully used by Staynew Filter Corporation in more than half a million filters for air transmission lines and internal combustion engines, has now been adapted in a new model to the filtration of water. The new filter has already proven its value, under actual working conditions, to steel mills, users of hydraulic systems and humidifying apparatus, chemical plants, factories, and to many other users.

Construction is simple and filtering action positive, all water passing through special fabric filter mediums possessing the advantages of high efficiency plus minimum restriction to water flow—advantages which are increased by the radial fin construction. This construction permits a large area of filtering medium to occupy a relatively small space. For example, a radial fin construction insert only 11 in. high by 8¼ in. in diameter possesses an active filtering area of 1325 sq. in.

There are no moving parts in the new filter, and the large filtering area permits long periods of operation without any attention whatever.

NEW SELF-CONTAINED LUBRICATING SYSTEM

▲ With the general speed-up of production and the continuous use of machines for longer periods per day, the subject of efficient lubrication has become vital in today's industrial program. Observing the need for a new type of lubricating system, S. F. Bowser and Company, Inc., has developed a series of new lubricating units for use in industrial plants. This new equipment, properly called self-contained lubricating units, has many advantages over previous systems which usually consisted of various integral parts such as pumps, lubricators, pipes, etc., all of which had to be assembled and engineered on the job. These new units do away with this inconvenient method of installation, as all the equipment necessary for lubrication is contained within the

15 ton (two 7½ ton hooks), 100'-0" span Cleveland all-welded crane in a modern mill. Two other Clevelands in background.

FOR THE HARD JOBS TRY CLEVELANDS

For continuous year in and year out service Cleveland all-welded mill cranes have a remarkable record. Despite severity of service and often-times considerable abuse, Clevelands will be found doggedly at it.

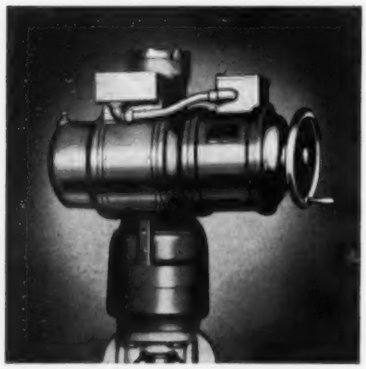
Their all-welded construction insures all parts remaining firm and intact. Usual loosening is eliminated. There is no binding with resultant abnormal wear. All working parts continue to run as smoothly as when the crane is first erected.

Among steel mill engineers who know, who have tried them all, Cleveland all-welded cranes rate high.

THE CLEVELAND CRANE & ENGINEERING CO.
Wickliffe, Ohio

CLEVELAND CRANES
ALL-WELDED OVERHEAD TRAVELING CRANES
Other products: CLEVELAND TRAMRAIL and STEELWELD MACHINERY

one unit, completely assembled. The only installation work is the hook-up of the pipe lines and wiring.



This new unit has all of the equipment necessary for lubrication contained within the one unit, completely assembled. The only installation work is the hook-up of the pipe lines and wiring.

The units are made in numerous sizes and in several types to meet a variety of conditions. Briefly, the units store the oil, pump it, filter it, and circulate it to the machine. Some models provide alarms to indicate when the feedline pressure drops to the pre-determined low point for which the switch has been set.

CLAIRTON WORKS WILL REBUILD BLAST FURNACE

▲ Carnegie-Illinois Steel Corporation, a United States Steel Corporation subsidiary, is rehabilitating its No. 3 blast furnace at the Clairton Works in Pennsylvania. Last operated in October, 1930, the furnace is expected to be in blast by May 1. Return of the Clairton furnace to the active list will make possible an additional annual pig iron production of 200,000 net tons.

This company has 32 active and 4 reserve blast furnaces in the Pittsburgh district.

NEW EXHAUST HEAD USES BAFFLE-TYPE SEPARATORS

▲ A new exhaust head developed by the Cochrane Corporation insures the separation of condensate and oil from steam discharged to atmosphere and thereby prevents raining of water and oily condensate upon the roof or ground below, at the same time discharging clean, dry steam noiselessly.

The new exhaust head incorporates the principles of the company's baffle-type steam separators used for removing oil and moisture from steam lines. Exceptional port area produces low steam velocity and minimizes pressure loss. Steam is whipped sidewise and causes projection of entrainment against ribbed baffle surfaces. The high ribbed baffles exert a scrubbing action in addition to the centrifugal purging force. The exhaust head is of one piece semi-steel construction for 4 to 12 in. sizes and of welded plate for larger sizes.

SIXTY DAY RECORD FOR BLAST FURNACE REBUILD

▲ Wisconsin Steel Company, a division of the International Harvester Company, has just achieved what may be a record for speed in reconditioning a blast furnace. The No. 2 blast furnace at South Chicago, Illinois, a 600 ton daily capacity stack, was blown out December 1, and on January 30 was blown in again completely relined and rehabilitated. This job, which normally requires 90 days, was completed in the 60 day period. Urgent need for iron production prompted the dispatch in getting the furnace repaired and back into service.

NEW CONVERTIBLE CRANE FOR MATERIAL HANDLING

▲ A new, lightweight ¾ yd. convertible shovel and dragline crane, Model 75, has been developed by the Link-Belt Speeder Corporation. All-welded steel construction has replaced castings in the new crane. The power plant is a heavy duty gasoline or diesel engine with a smooth-running roller chain drive. Alloy steel, machine-cut spur gears drive the reverse and drum shafts. These turn in heavy bronze bearings.

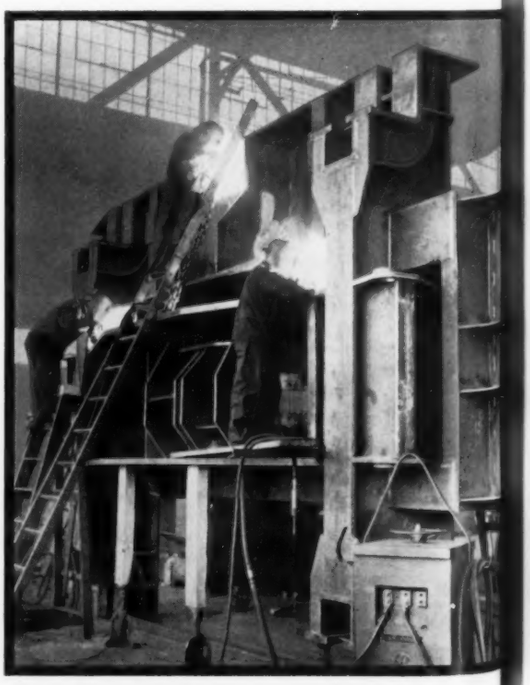
External band clutches enable the operator to "feel" the load at all times. This sensitivity, plus external band brakes operated by automotive type pedals, results in perfect control of the load and the greatest accuracy in placement. All brake bands are instantly accessible for adjustment and can be removed easily for relining. A large diameter turntable and long, wide crawlers give the new crane extra stability on slopes and in heavy digging. A roller path machined on a bevel permits the use of large, wide-faced conical rollers that revolve without slippage. The upper and lower frames are connected by a heavy alloy steel center quill with large adjusting nut.

Controls operated from within the cab permit steering in both directions, either gradual or sharp, regardless of the relative position of cab and lower base. A positive traction lock, controlled from the cab and engaging in three positions, prevents movement of the crawlers while working, eliminating any necessity for chocks or blocking.

NEW STEAM LOCOMOTIVE FOR GENERAL PLANT USE

▲ A new steam locomotive which embodies several design and construction improvements over existing equipment has been completed by the H. K. Porter Company. The new

This all-welded trolley frame, under construction in the Wickliffe, Ohio, plant of the Cleveland Crane and Engineering Company, is believed to be the world's largest. The frame alone will weigh 3½ tons and have an overall length of 23 ft. 5 in. by 15 ft. 6 in. The crane for which this frame is being built is one of three duplicates to be used in connection with heavy defense work.



locomotive is ideal for steel mill, switching and general plant use.

Designed for use on 30 in. track up to standard gauge, the new locomotive is 7 ft. 4 in. wide, 10 ft. 6 in. high and 22 ft. 10 in. long from bumper to bumper. Four 42 in. diameter drive wheels, connected, provide a tractive force of 26,000 lb. Despite its large tractive force, the locomotive is designed so that it can take a curve of 50 ft. radius. It is of the saddle tank type, with boiler 56 in. in diameter, designed for a working pressure of 180 lb. per sq. in. Bituminous coal is the fuel used.

Frames are of heavy slab steel, thoroughly annealed to insure ruggedness and perfect alignment. Slab steel bumpers are provided at front and rear, and boiler is well secured to frames, allowing freedom for expansion and contraction. Cab is constructed of sheet steel, with clear wire glass windows at rear, and side windows with steel sash, vertically telescoped. Total weight of the locomotive, in working order, is 118,000 lb.

DESIGN HYDRAULIC TRUCK FOR HEAVY DUTY SERVICE

▲ After years of experimental design and numerous grueling field tests, the engineers of the Yale and Towne Manufacturing Company now offer industry the perfectly balanced hydraulic hand lift truck, called the "Load King." Featuring easier lift, easier steer, greater safety to operator, lower maintenance and controlled lowering of loads, the "Load King" is built for continuous heavy-duty service. (Capacities: 3500, 5000, 6000 and 8000 lb.)

This hydraulic truck is blueprint designed throughout. All parts are specially made for hand lift truck service and the design makes maximum use of every construction feature essential to perfect heavy-duty hand lift truck operation. The hydraulic lifting unit of the hydraulic truck is self-contained and totally enclosed—has no needle valves to get out of order. The pump unit is equipped with automotive type piston and piston rings, which guarantee maximum pressure at all times. Hardened and ground automotive type poppet valves, operating on hardened and ground valve seats, insures trouble-free operation.

The larger diameter lift ram is solid steel, precision-ground and polished. Operating in a cylinder equipped with chevron leather seals encased in bronze bushings, it assures maintenance of oil pressure to support loads in elevated position. The large size ram lowers oil pressure 50 per cent, increases packing life and greatly reduces possibility of valve leakage. The hydaulic unit has a five pint oil reservoir, requires less frequent refilling, means less chance of foreign matter entering the reservoir and insures continuous truck operation. The pump unit is fully guarded and protected from outside shock and possible damage.

The design reduces truck construction to only essential parts. One-piece frame serves the double purpose of elevating platform and elevating frame. All parts consisting of frame, rear wheel assembly and front head assembly, are designed with a maximum factor of safety in all models.

Protect Your Property with
CROUSE-HINDS
Searchlights and Floodlights

The surest way to guard your property at night is to use the protective power of light. Floodlight the most important areas and if additional protection is desired, mount one or more searchlights at high points where they can be controlled by watchmen and used to keep a check on more distant points.

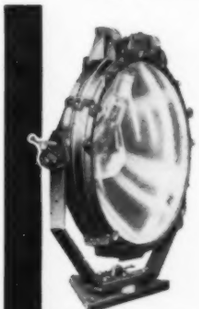
Crouse-Hinds searchlights can be operated from storage batteries in an emergency when other lighting may be out of commission.

Write for additional information on protective lighting. We will gladly give you a specific recommendation for lighting your property.

Type DCE Searchlight Trunnion Mounting

Standard Searchlights can be furnished in various sizes to meet all requirements.

Type DCX Searchlight Pilot House Lever Control



Type LCE-24 Floodlight

Type LCE-1120 Floodlight

Type ADE-16 Floodlight

Floodlights are shown with standard base mountings. Various other types are available so that the proper base may be selected for each installation.

Type DCX is designed to be mounted on a roof with control from below by means of levers. The control stem can be any length.

CROUSE-HINDS COMPANY
SYRACUSE, N. Y., U. S. A.

Sales Offices: Birmingham — Boston — Chicago — Cincinnati — Cleveland — Dallas — Detroit — Houston — Kansas City — Los Angeles — Milwaukee — Minneapolis — New York — Philadelphia — Pittsburgh — San Francisco — Seattle — St. Louis — Washington

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CROUSE-HINDS COMPANY OF CANADA, LTD., *Main Office and Plant:* TORONTO, ONT.

JOLIET WIRE PLANT TO ROLL STAINLESS STEEL

▲ American Steel and Wire Company is in the process of installing equipment and altering existing facilities for the rolling of stainless steel and other special high quality rods at the Joliet, Illinois, plant. Equipment is being added to the present merchant rod mill which will allow the rolling of more highly specialized products. The installation includes five 10 in. stands, two reels, a conveyor and two new billet heating furnaces, with provision for a third, besides the necessary handling, driving and control equipment.

The new stands are added to the present two 18 in. roughing stands and seven 12 in. finishing stands. A new building approximately 60 ft. square is being built to house the furnaces.

PRINTING MACHINE FOR DRAFTING ROOM

▲ New simplicity of design and new operating usefulness are embodied in a new printer just announced by Charles Bruning Company, Inc. Known as the "Model 55 BW Printer," this machine is said to be the most compact printer of its capacity on the market, since it measures only 32 in. wide, 62 in. long, and 48 in. high.

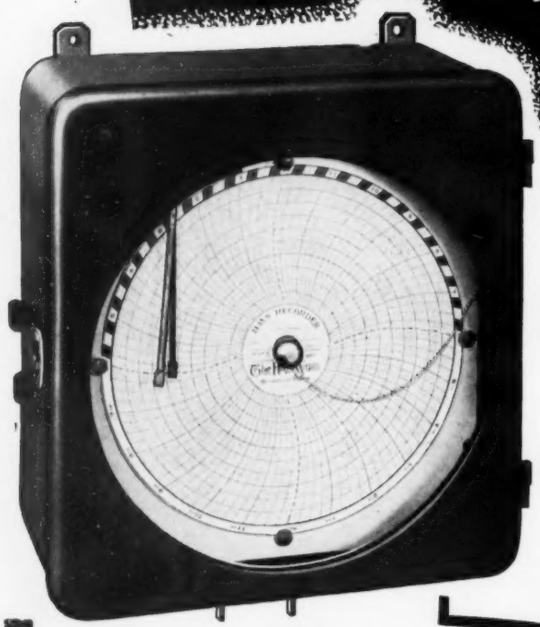
This 42 in. printer operates with either cut sheets or roll stock, and prints ink tracings at from 12 to 15 ft. per min. A full-view speed indicator placed at the center of the front, above the feed board, makes the speed of the machine readily visible to the operator at all times.

An exclusive feature of the printer is its new print and tracing return. The entire top of the machine serves as a return tray, and the return is so designed that the tracing enters the tray on top of the print, in exactly the same way as it is inserted in the machine. No reversing of the tracing is necessary when reinserting it into the machine. Furthermore, as they emerge from the printer onto the tray, exposed sheets stack themselves almost automatically.

The entire top of this printer serves as a return tray, with the return designed so that the tracing enters the tray on top of the print, in exactly the same way as it is inserted in the machine.

The light source of the new printer is a 55 watt new-type mercury vapor quartz lamp. This quartz lamp furnishes uniform exposure, without flickering, and is guaranteed for a life of 1000 hr. The lamp is installed in a revolving 9 in. pyrex contact cylinder which provides almost perfect contact.

REGISTERS DRAFT, PRESSURE AND DIFFERENTIAL



in SOAKING PITS • ANNEALING FURNACES • OPEN HEARTHS • SLAB MILLS

HAYS "OT" DRAFT RECORDER Results in a better product because it gives a correct indication of furnace atmospheres. Built husky enough to stand the severest steel mill conditions yet sensitive enough to register accurately in increments of .0025 in. water. Employs the famous Hays Slack Leather Diaphragm—self sealing—not damaged under sudden excess pressures. Two draft values, two pressure values, two differential values, or a combination of any two of these three values may be recorded. Or a temperature recorder may be substituted for one of these values. Send for descriptive literature. Write to 955 Eighth Avenue, Michigan City, Indiana.

The HAYS CORPORATION
SINCE 1907 COMBUSTION INSTRUMENTS AND CONTROL
MICHIGAN CITY, INDIANA, U.S.A.

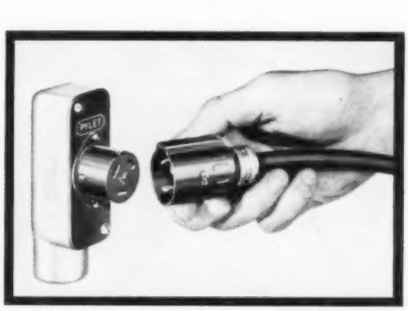
RAISE COKE PRODUCING CAPACITY IN CHICAGO

▲ Carnegie-Illinois Steel Corporation materially increased the coke production in the Chicago district by placing two new batteries of by-product coke ovens in operation at the Gary Works. The new units, of 71 ovens each, replaced No. 10 and No. 12 batteries formerly comprised of 70 ovens each.

Work was started on the replacements last year and both of the batteries were restored to operation by January 25, 1941. These additional batteries now give the Carnegie-Illinois Steel Corporation a total of 1258 coke ovens in the Chicago region with peak annual production possibilities exceeding 5,000,000 tons annually.

INTRODUCE HEAVY DUTY PLUGS AND RECEPTACLES

▲ A new line of heavy duty plugs, receptacles and cord connectors for use with portable electrical equipment, has been introduced by the Pyle-National Company. While this line has the same electrical rating and



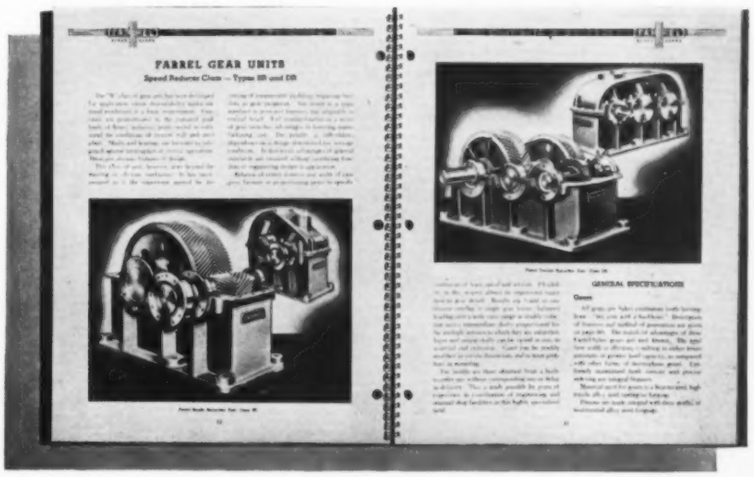
is approximately the same size as standard attachment plugs and outlet receptacles, it embodies the heavy duty design and substantial construction features of the larger Pyle-National "Triploc" plugs and receptacles for industrial use.

All 2, 3, and 4 pole contact units are interchangeable, to permit using a wide variety of plug shells and receptacle housings to make any desired assembly combination. Contact units are reversible, for safety protection. The enclosed female contacts may be assembled in either plug shell or receptacle housing, depending upon which is connected to the live line side of the circuit. This allows the use of extension cords with cable connectors, and convenient receptacles mounted on portable equipment, without the hazard of exposed live contacts.

Contact units are molded bakelite with renewable self-aligning flat bronze contacts and side-wired binding screw terminals. Plugs cannot be inserted incorrectly.

ALLEGHENY-LUDLEM LETS EXPANSION CONTRACTS

▲ Allegheny-Ludlum Steel Corporation recently announced the awarding of contracts for the equipment in its $2,000,000 expansion program at the Brackenridge and West Leechburg, Pennsylvania, plants, and work will be rushed on the new facilities to enable the company to increase out-



FARREL GEAR UNITS

Provide Built-to-Order Results without Corresponding Cost or Delay in Delivery

Here are speed reducing units—Farrel Types SR and DR—that give you the benefits of general standards without sacrifice of freedom in engineering design and application. Here are gear units that meet the obvious requirements—cases proportioned to the repeated peak loads of heavy industry; joints sealed to withstand the conditions of cement mill and steel plant; shafts and bearings factored to safeguard against interruption of operation. They also provide these additional features and advantages:

Relation of center distance and width of case gives the designer latitude in proportioning gears to specific conditions of load, speed and service. The result is an engineered exactness in detail, with the benefits found in continuous overlap in single gear trains; balanced loading over a wide ratio range in double reduction units; intermediate shafts proportioned for the multiple stresses to which they are subjected. Input and output shafts can be varied in size, in material and extension. Cases can be readily modified in certain dimensions to meet problems in mounting.

Farrel Gear Units of this class are available in both single and double reduction types. For more complete details write for a copy of our Catalog No. 438.

FARREL-BIRMINGHAM COMPANY, INC.
366 VULCAN STREET BUFFALO, N. Y.
FARREL SYKES GEARS *The Gear with a Backbone*

put of special steels for the national defense program.

Electric steel capacity will be increased by approximately 4000 tons per month by the addition of two additional electric melting furnaces at the Brackenridge plant. This represents an increase of approximately 50 per cent in such capacity at the Brackenridge plant, as the present electric capacity is a little over 8000 tons per month. The company also produces electric steel at other plants and its aggregate capacity is approximately 160,000 tons.

Contracts for additional rolling mill equipment to handle the enlarged tonnage production, were included in the present awarding. This rolling mill equipment will be installed mainly at West Leechburg, and one of the projects is said to be a four-high, 42 in. mill being designed to roll extremely thin stainless steel.

WIDEN REVERSING STAND IN MILL AT HOMESTEAD

▲ Carnegie-Illinois Steel Corporation is installing additional facilities for the production of light armor plate and shafts at the Homestead Works and the Clairton Works. The new expansion program, involving installations not previously announced, will provide for casting pits and handling facilities for large ingots at Clairton and for preheating and annealing furnaces, and casting and handling equipment at Homestead.

The 100 in. plate mill at the Homestead Works is being altered to the extent of widening the reversing roughing stand so that plate up to 120 in. wide may be reduced in this phase of the finishing mill. The finishing stands are not being widened. Apparently the reversing stand is being utilized to manufacture 120 in. plates which are removed at this point for further processing such as heat treating and final finishing.

NEW LITERATURE

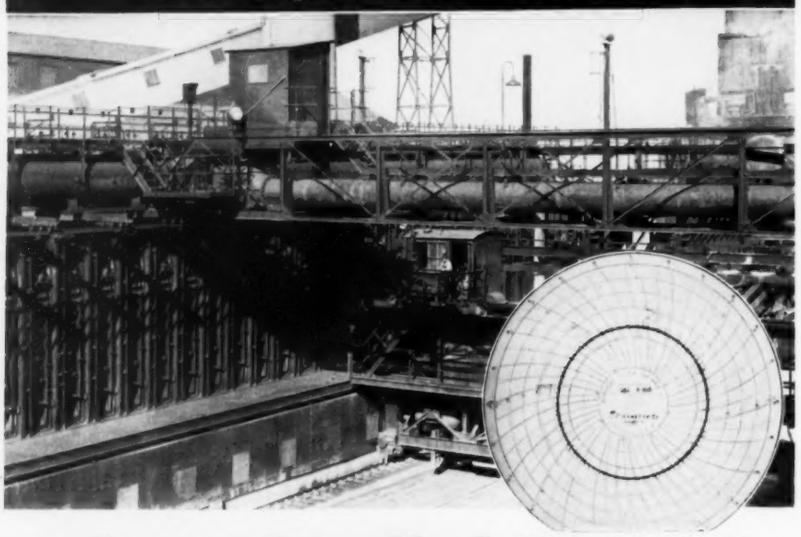
▲ Leeds and Northrup Company has issued a catalogue listing everything needed to check thermocouple pyrometers. This brochure not only illustrates and describes portable equipment for plant tests under actual operating conditions, but the laboratory apparatus to standardize it. Recommendations are also included so that pyrometer users should have little difficulty in choosing checking apparatus best suited to their needs.

A copy of Catalogue E-33A-503 will be sent upon request, the address is Leeds and Northrup Company, 4934 Stenton Avenue.

▲ B. F. Sturtevant Company has available a new booklet entitled "Sturtevant Downblast Heater," describing the new unit heater which projects all of the heat downward to the working level. This heater is particularly suited for use in buildings with high ceilings, above crane rails, or wherever it is necessary to project heat downward from a considerable height. Included in the booklet are capacity tables, with instructions as to the use of each table.

Heating problems may be solved by sending for this booklet to the B. F. Sturtevant Company, Hyde Park, Boston, Massachusetts.

One of the toughest jobs for a pressure control



—is being handled in this plant

• Scores of charts like this showing collecting main pressure maintained within ½ millimeter could be cited to prove the effectiveness of Askania Control.

IT is essential that the gas pressure in the collecting main of a coke oven battery be maintained within extremely close limits, and this job is made particularly difficult by erratic peaks caused by the methods employed for smokeless operation.

But the Askania Constant Pressure Control in this plant makes this tough job seem easy—holds the pressure to remarkably close limits—holds it day after day with that unvarying accuracy which so many operating men have found to be the unduplicated advantage of Askania Control.

In more than fifty installations of this type, made during the last few years, there has been *no interruption* in service and practically no maintenance. What we have accomplished here, we can accomplish for you.

ASKANIA REGULATOR COMPANY
1603 South Michigan Avenue, Chicago, Illinois

ASKANIA CHICAGO *Automatic* CONTROL

"IF IT CAN BE MEASURED—WE CAN CONTROL IT"

Defenders of Defense

Most of the steel that is used in America's vast armament program is being rolled on TIMKEN Bearings. TIMKEN Roll Neck Bearings made the high-speed strip mill practical. An overwhelming majority of modern strip mills—hot and cold—are equipped with TIMKEN Bearings.

On steel mill roll necks, in mill drives, pinion stands, approach and run-out tables and a multitude of auxiliary equipment a great army of TIMKEN Bearings is going into action to defend the steel industry against friction, wear, load, shock, delay and waste in order that America's defense program may not lag.

THE TIMKEN ROLLER BEARING COMPANY, CANTON, OHIO

TIMKEN
TAPERED ROLLER BEARINGS

Manufacturers of TIMKEN Tapered Roller Bearings for automobiles, motor trucks, railroad cars and locomotives and all kinds of industrial machinery; TIMKEN Alloy Steels and Carbon and Alloy Seamless Tubing; and TIMKEN Rock Bits.

ITEMS OF INTEREST

Guy T. Avery has been promoted to works manager of the Acme Steel Company's plant at Riverdale, Illinois. Associated with the company since February, 1920, he recently was assistant works manager and has directed the processing of general line items which include hoops for barrels, steel strapping, galvanized and painted strip steel. Mr. Avery is a graduate of the University of Illinois' school of engineering.

W. J. Huge was appointed assistant to division superintendent, coke plant and blast furnaces, quality control, Gary Works, Carnegie-Illinois Steel Corporation. Mr. Huge has been assistant to superintendent of blast furnaces at the same plant.

Ragnar Overberg has been made assistant to division superintendent of steel production, quality control, Gary Works, Carnegie-Illinois Steel Corporation. Mr. Overberg until this promotion was assistant to division superintendent, central mills at the Gary Works.

Ralph W. Dickson, laboratory foreman, Gary Works, Carnegie-Illinois Steel Corporation, since 1937, has been made assistant to division superintendent of the central mills, quality control, at the same plant.

D. L. Simpson, a metallurgist since 1939, becomes chief observer, west mills, quality control, at the Gary Works of the CarnegieIllinois Steel Corporation.

G. Donald Spackman has been appointed general manager of the Lukens Steel Company, Coatesville, Pennsylvania, and its subsidiaries. Mr. Spackman was born in 1895 at Coatesville, attending Coatesville high school and Swarthmore College. He was graduated from the latter in 1917 with the degree of bachelor of arts, and received his mechanical engineering degree from the same school in 1924. In the summer of 1919, he joined Lukens Steel Company, serving in the mechanical department and handling steam, hydraulic and combustion problems. In December, 1920, he was appointed fuel engineer for the company, serving in that capacity until August, 1925, when he was appointed superintendent of the flanging department.

In August, 1929, Mr. Spackman was appointed assistant general superintendent of Lukens Steel Company. When the Lukenweld division was formed in May, 1930, he was elected president of that division. In September, 1936, he was appointed general superintendent of Lukens Steel Company, holding that position until his present appointment.

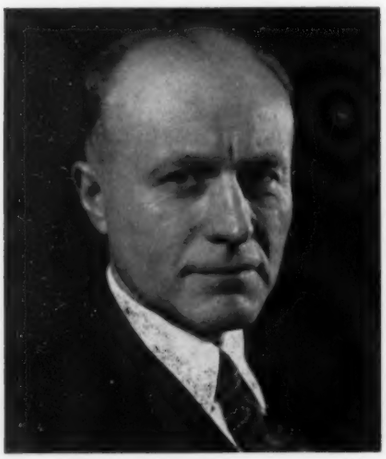
F. L. Toy was appointed assistant to manager of technical development for the Carnegie-Illinois Steel Corporation, Pittsburgh, Pennsylvania. Mr. Toy was born in 1886 and graduated from Lehigh University in 1909 with degrees in electrical engineering and metallurgical engineering, and later completed a postgraduate, non-resident course at Harvard University in metallography.

Mr. Toy has been with the Carnegie-Illinois Steel Corporation continuously since 1909, serving as metallurgist at the Homestead steel works until 1920, when he was made superintendent of the open hearth department at that plant, in charge of all steel-making activities. From 1933 to 1937, in addition to his open hearth duties, Mr. Toy acted as management's representative in charge of all industrial relations at the Homestead Works, and in 1937 he was made assistant general superintendent in charge of industrial relations.

A. N. Swanson was recently made chief metallurgist of the Gary Works, Carnegie-Illinois Steel Corporation. Mr. Swanson was first employed at the Gary Works in 1922 in the metallurgical department, where he served in various capacities until 1934, when he became assistant chief metallurgist. He was appointed assistant to division superintendent of the west mills in 1940, the position he held until receiving his new post.

L. E. Smith, formerly superintendent of masonry for the Continental Steel Corporation, Kokomo, Indiana, was appointed chief engineer of the company's Kokomo plant, succeeding L. H. Mandeville, resigned. Mr. Smith has been connected with the company for the past six years. He was graduated from Purdue University in 1925.

W. J. HUGE



G. D. SPACKMAN

F. L. TOY

Robert Murray has been appointed superintendent of the New Haven Works of American Steel and Wire Company, a subsidiary of the United States Steel Corporation. Mr. Murray has previously been assistant superintendent of the plant. His experience with American Steel and Wire dates back to 1920, when he was first employed at Worcester, Massachusetts. In 1922, he went to New Haven and held several positions culminating in his present promotion.

A. F. White has been appointed assistant to the manager of operations, Pittsburgh district, American Steel and Wire Company. Mr. White has spent thirty years at the Donora plant. After having been in the employ of Carnegie Steel and Illinois Steel Companies, both subsidiaries of United States Steel Corporation, he joined the American Steel and Wire Company as chief chemist at Donora in 1910. He worked through various positions at the steel works until he became general superintendent of Donora in 1938.

L. F. McGlincy succeeds A. F. White as general superintendent of the Donora steel and wire works of the American Steel and Wire Company. Mr. McGlincy joined American Steel and Wire Company at Worcester in an industrial engineering capacity in 1924. He worked through the rolling mills and open hearths, becoming a superintendent in 1935. In 1939 he was appointed division metallurgist in the main office. **Richard R. Snow,** assistant superintendent of open hearths and hot rolling mills, Worcester, will assume Mr. McGlincy's position as division metallurgist in Cleveland. **U. F. Corsini,** assistant general foreman, Worcester rod mills, will become assistant superintendent of open hearths succeeding Mr. Snow.

Elwood H. Koontz was appointed district manager at Minneapolis, Minnesota, for Reliance Electric and Engineering Company. Mr. Koontz joined Reliance in 1936 directly following his graduation from Massachusetts Institute of Technology. He goes to his new responsibilities in Minneapolis from Reliance's Philadelphia office where he has been a member of the sales engineering staff for the past three years. **Wilmer K. Schlotterbeck,** now in the application engineering department at Cleveland, succeeds Mr. Koontz in Philadelphia.

Orville T. Barnett has joined the welding electrode department of the Metal and Thermit Corporation, New York, New York, in the capacity of engineer of tests. A graduate of Armour Institute of Technology in chemical engineering, Mr. Barnett has a well-rounded background in the metallurgy of welding. He was formerly associated with Carnegie-Illinois Steel Corporation in the metallurgical control department, and later with Black, Sivalls and Bryson, Inc., of Oklahoma City, where he first did research and welding control work, and was later placed in charge of shop inspection. At the Metal and Thermit Corporation, all electrode test work, including manufacturing control testing at both the Jersey City and East Chicago plants, as well as research work on uses and applications of electrodes will be under his supervision.

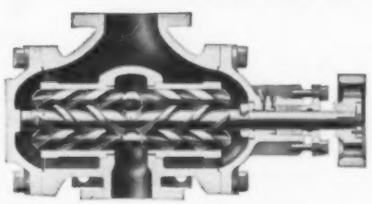
Dewey A. White was appointed manager of the newly opened Birmingham district office of the Okonite Company. Mr. White, who will have charge of the South Central Territory, will maintain headquarters at 1212 Comer Building, Birmingham, Alabama. He has been connected with the Okonite Company for seventeen years.

The South Atlantic Territory will continue to be handled by **George N. Brown** at 1606 Rhodes-Haverty Building, Atlanta, Georgia. **Robert E. Sontag** remains in charge of the Okonite Company's St. Louis office, which has been moved from the Ambassador Building to large quarters at 1406 Shell Building.

F. E. Fairman, Jr., has been appointed assistant manager of the switchgear division, central station department, of the General Electric Company, Philadelphia, Pennsylvania. Mr. Fairman, a native of Pittsburgh, Pennsylvania, was graduated from the United States Naval Academy in 1921. After spending some time in the fleet he resigned from the navy and entered the employ of General Electric in 1923, at the Baltimore Works as a switchgear engineer. He was transferred to the Pittsburgh office as a switchgear specialist in 1927, three years later becoming an industrial salesman handling steel mills. He returned to the switchgear division of the central station department at Philadelphia in 1933, becoming sales manager of the equipment section in 1939.

GOOD COMBUSTION *needs* STEADY PRESSURE

These three De Laval-IMO's are delivering Bunker C to the burners at a continuous, steady 300 pounds pressure in a large central station. The De Laval-IMO rotors displace oil continuously and uniformly without pulsation. Catalog 1-61 tells why.



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TRENTON, NEW JERSEY

Richard A. Geuder has been made manager of metal industry applications, Reliance Electric and Engineering Company, Cleveland, Ohio. Mr. Geuder obtained his bachelor of science degree in electrochemical engineering from Pennsylvania State College in 1929. He came directly to Reliance upon graduation and has been engaged in application engineering work for the company uninterruptedly since that time.

R. A. GEUDER

J. D. Hoffman has been promoted to manager of sales of the equipment section in the switchgear division at Philadelphia, taking over the work formerly handled by F. E. Fairman, Jr. Mr. Hoffman was born in Kansas City, Missouri, and attended Stevens Institute. In February, 1917, he entered the service of General Electric at Schenectady, leaving two months later to enter military service. In 1919 he rejoined General Electric in the testing department at Schenectady. He left the service of the company to go into business for himself, being re-employed by General Electric in 1922 in the switchgear department at Schenectady. In 1927, Mr. Hoffman was transferred to the central district as switchgear specialist at Chicago, and later at Detroit. In 1934, he returned to the switchgear division of the central station department at Philadelphia where he has been associated with the equipment section as assistant to Mr. Fairman.

Jay J. Seaver has become associated with Day and Zimmerman, Inc., engineers in Philadelphia, Pennsylvania. Mr. Seaver, a graduate of the University of Michigan with a degree of mechanical engineering, was associated with Arthur G. McKee and Company, Cleveland, Ohio, as vice-president and recently with H. A. Brassert and Company, Pittsburgh, Pennsylvania, as vice-president.

Louis R. Botsai, has been appointed manager of the gearing department at the East Pittsburgh division of the Westinghouse Electric and Manufacturing Company. Mr. Botsai has been sales manager of the company's small motor division in Lima, Ohio, for the past three years. Before that he was, for eight years, sales manager of gearing apparatus at the Westinghouse Nuttall Works in Pittsburgh.

Born in Birmingham, Alabama, in 1895, Mr. Botsai was graduated from Alabama Polytechnic Institute in 1915, and then took advanced study at Carnegie Institute of Technology. He joined the Westinghouse company as a student engineer in 1915, and in five years attained the position of general manager of steel mill electrification at East Pittsburgh. After that he held such various titles as consulting refrigeration engineer, sales engineer, and central district industrial manager.

D. S. Mix was assigned responsibility for media and publishers relations, in General Electric Company's publicity department, Schenectady. Under his new duties, Mr. Mix will have responsibility for the work formerly handled by the late F. R. Davis.

A native of New Haven, Connecticut, Mr. Mix was graduated from the Sheffield Scientific School of Yale University in 1917, joining General Electric immediately thereafter on editorial work in the publicity department. The following year he left the company for military service, returning in 1919, when he was again assigned to editorial work in the publicity department. After promotional work in the commercial service section of the same department, he was made a contact man with responsibility for directing the advertising and sales promotion activities of a large number of apparatus lines.

In 1929, Mr. Mix was made copy chief of the department in addition to his duties as contact man. Since 1932, he has devoted his time to publicity department training programs, personnel, and special assignments, which he will continue to handle.

Obituary

William I. Sivitz, 53, branch manager for the Duriron Company with offices in the Empire Building, Pittsburgh, Pennsylvania, died recently. Mr. Sivitz was a member of Carnegie Institute of Technology's first graduating class in 1908. He was an associate member of the Association of Iron and Steel Engineers, and was also president of the Pittsburgh chapter of the American Institute of Chemical Engineers.

Albert T. Keller, former chief engineer of construction of the Bethlehem Steel Company, Bethlehem, Pennsylvania, died recently. Mr. Keller, a native of Pittsburgh, had been associated with the steel industry for fifty years, having first been connected with the Mesta Machine Company and the Carnegie Steel Company. He joined the Bethlehem company in 1916 as chief engineer of construction at Sparrows Point, Maryland. In 1923, he was transferred to Bethlehem to serve in the same capacity. He retired in 1939, but was recently recalled to active service.

David Milne, machine shop superintendent of Farrel-Birmingham Company, Inc., Ansonia, Connecticut, for the past twenty-one years, died recently.